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TECHNICAL RISK ASSESSMENT OF EXTENDED CONFIGURATIONS OF THE M113A1E1

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
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This study assesses the technical risk associated with development and employment of a stretched M113A1E1 vehicle (SM113) in the IFV/CFV role. The analysis is limited to technical risk, thus excluding other types of program risks such as those associated with cost and schedule. The analysis addresses the SM113 in various configurations and in most cases makes comparison to the M113A1 and to the M113A1E1 (not extended). Primary concern is for the effects of weight growth, and specific attention is given to the cooling system, engine, transmission, final drive, suspension, track, hull and weapons station.

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TECHNICAL RISK ASSESSMENT OF
EXTENDED CONFIGURATIONS OF
THE M113A1E1

I. INTRODUCTION

This study was conducted in response to a request from the Infantry Fighting Vehicle/Cavalry Fighting Vehicle Special Study Group for an assessment of the technical risk associated with development and employment of a stretched M113A1E1 vehicle (SM113) in the IFV/CFV role. The analysis is limited to technical risk, thus excluding other types of program risks such as those associated with cost and schedule. The analysis addresses the SM113 in various configurations and in most cases makes comparisons to the M113A1 and to the M113A1E1 (not extended). There is one excursion, that being for the IFV chassis combined with the ITV weapons station.

There are four primary configurations considered in this risk analysis. These are:

Chassis	Turret	Weight (lb)
SM113	ITV	29,500
SM113	TAT	31,500
SM113	BAT	33,500
SM113	TBAT	35,000

In addition there are two baseline configurations, which are as follows:

Chassis	Turret	Weight (lb)
M113A1	NONE (.50 cal MG)	24,600
M113A1E1	ITV	26,500

Finally, there is the excursion mentioned with the IFV.

Chassis	Turret	Weight (lb)
IFV	ITV	41,900

Data sheets on each of these configurations, as developed by TARADCOM, are included as Appendix B.

II. APPROACH

Since there is essentially one chassis common to most alternatives under consideration here, i.e. the SM113, the task is one of determining risk growth with configuration weight growth, rather than one of determining relative risk associated with very different alternatives. With this in mind, the approach used is to assess the effect of overall vehicle weight on expected performance of the critical vehicle systems or components.

The risk is examined in three areas, as appropriate for each component or system. The first concerns the structural integrity of the component at the loads anticipated for each level of vehicle weight. The risk is one of exceeding fundamental design limits, characterized by early life or catastrophic failure. The second is the risk of not attaining satisfactory levels of performance for the system or for the overall vehicle as limited by the system. The third risk area is that of insufficient growth potential i.e. ability to successfully handle further growth in gross vehicle weight.

The specific components which are investigated and the areas of risk deemed appropriate for each investigation, are shown in the following array:

Component	Type of Risk		
	Design Integrity	Performance	Growth Potential
Cooling System	X	X	X
Engine	X	X	X
Transmission	X	X	X
Final Drive	X	X	X
Suspension	X	X	X
Track	X	X	X
Hull	X	X	X
Weapons Station	-	X	-

An overall mobility assessment is made of each vehicle configuration, which serves to indicate the effect of vehicle weight growth on power train effectiveness. This analysis is included as Appendix A.

In addition to the risk areas mentioned earlier, there is also the risk that reliability and durability will be degraded to an unacceptable level with weight growth, if other factors are held constant. An independent AMSAA RAMD evaluation is therefore included.

the desired objective. The performance of the SM113 under low speed, high tractive effort conditions will be similar to that of the M113A1-EPC-7C and cooling under those conditions will be acceptable. There are at least two negative aspects of this arrangement. First, the final drives work harder and therefore generate more heat. This may not be a significant problem. At the limiting condition for transmission cooling, final drive temperatures are more than 100^{o}F below their limit, see Section III.A.4.

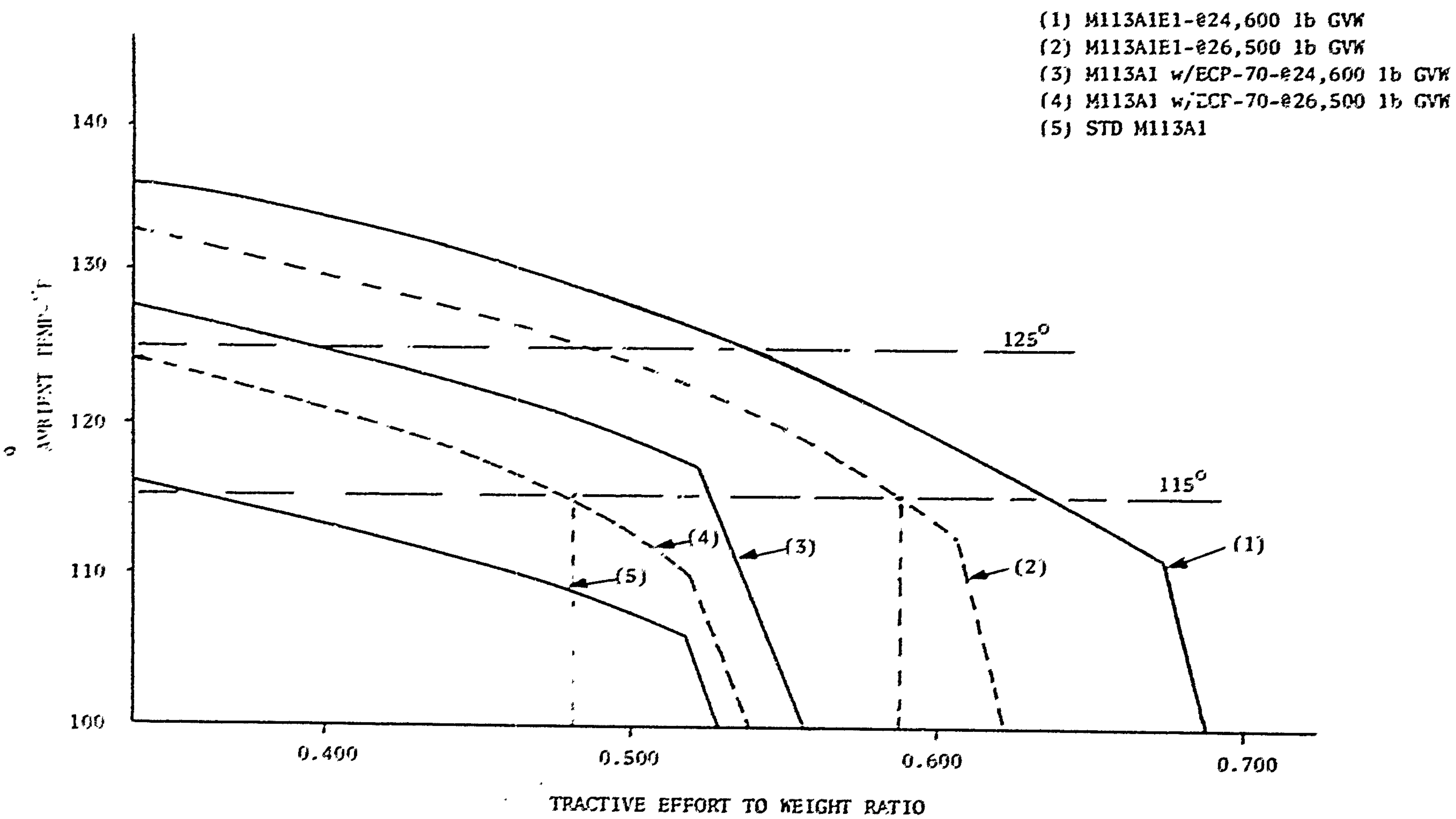
The other negative aspect is that with the higher final drive ratio, vehicle top speeds will be lower and time to traverse a given distance will be increased. The significance of this lower speed in terms of mission effectiveness is beyond the scope of this study.

In terms of risk assessment, the vehicle will be designed to operate up to the limit of satisfactory cooling at 115^{o}F. The probability of any vehicle actually operating under this condition and at low speed and high tractive effort for a significant interval is low but it does exist-as does the probability of operating at even higher temperatures.

The modified cooling system should not have any unique reliability problems. There appears to be a critical alignment problem with drive belt pulleys. There may be problems with trash and dirt build up on the radiator inlet. These are minor problems that can be controlled by proper maintenance. Outweighing these is the essential elimination of the problem of oil and sludge build up on the radiator fins that occurred in the M113A1. True the system has not been adequately tested but there is no doubt that it is better than the ECP-70 system.

This system does have some growth potential (TARADCOM is currently working on a more efficient fan).

FIGURE 3.1 M113A1 FAMILY OF VEHICLES
MAXIMUM AMBIENT TEMPERATURES FOR ADEQUATE COOLING



Finally, a review was made of an earlier risk analysis prepared by Battelle as part of the IFV Concept Evaluation Study. Based on that review, comments are provided in this report on the methodologies of the respective studies, and on the relative complexity of the SM113 and the IFV.

III. ANALYSIS

The following sections contain the rationale for arriving at the assessment of risk associated with the principal automotive components, as well as the RAM assessments, for each configuration.

A. Component Assessments

1. Cooling.

The standard M113A1 has a continual history of cooling problems. One phase of the current Product Improvement Program is an improved cooling system. This system has undergone some testing but not enough to fully assess its capability to adequately cool the PIP power train at 115°F.(1) It is certainly better than the current system, better even than the ECP-70 system currently used in M113A1 vehicles being built for foreign sales. Both systems have been run in the TARADCOM cooling model. Results are presented in the inclosed curve (Fig 3.1) which is derived from data prepared by TARADCOM. The curve for RISE power at 26,500 lb GVW is based on test data. The other curves are derived from the model. The figure shows that at 115°F, the M113A1E1 with the improved cooling system, the RISE power train and weighted to 26,500 pounds will cool acceptably at any tractive effort to weight ratio (TE/W) up to 0.58. The standard M113A1 at the same weight but with the ECP-70 cooling system was acceptable up to a TE/W of 0.49. This configuration is currently being built and delivered overseas by FMC at 24,900 lb GVW. In the model it was upweighted to 26,500 to allow direct comparison with the M113A1E1.

When the upweighted SM113 was proposed, cooling was recognized as a possible problem. TARADCOM proposes to limit the cooling load to that found to be acceptable on the M113A1E1. (Since the same power plant and cooling system are being used.) The other constraint was performance. The SM113 had to be capable of performing at least as well as the current M113A1 with ECP-70 cooling. In other words, it had to be capable of operation at a TE/W of at least 0.49 without exceeding the cooling load generated by the M113A1E1 at 0.58 TE/W. For a given engine/transmission output, the tractive effort is essentially constant so as vehicle weight increases, TE/W decreases proportionally. To maintain the specified ratio of TE/W, tractive effort must be increased but without increasing engine/transmission output and thereby increasing cooling load. TARADCOM proposes to accomplish this by increasing the final drive ratio as required. The new ratios are given in Section III.A.4. This modification will accomplish

(1) Note: TARADCOM is using a cooling criterion in this instance associated with a 115°F ambient temperature. It is noted however that AR 70-30 requires a 125°F criterion and the revised draft AR 70-30 requires a 120°F criterion.

2. Engine.

The 6V-53 engine is a proven design. It has been performing satisfactorily for years in commercial trucks, construction equipment, generator sets and other stationary equipment. The turbocharged version of this engine, the 6V-53T, was first used, with an aluminum block, in the M551 ARAAV vehicle. Later, a cast iron block version was retrofitted. This engine was rated at 300 horsepower and has been performed satisfactorily in test of the M551 at over 34,000 lb GVW. The same engine was used successfully in the XM800T ARSV prototype vehicle, though at only 19,000 pounds GVW. The 6V-53T engine is now being tested as a part of the RISE PIP for the M113A1E1. It will also power the SM113 at GVW's up to 35,000 pounds. There has been some apprehension concerning the ability of this engine to perform satisfactorily in a vehicle of this weight. There are several indications that these fears are not justified. Five of these are listed below:

a. It has been tested successfully in the M551 operating at 300 HP.

b. It has successfully passed the NATO 400 hour endurance test. This is the standard Army engine qualification test.

c. It is being used in a derated mode - from 300 HP to 275 HP.

d. The primary failure mode in the past has been from overheating. The modified cooling system should eliminate most of those failures.

e. Although the vehicle weight increases, the engine will not be required to develop higher outputs. The increased vehicle torque requirements will be obtained by increasing the final drive ratio. The manufacturer believes, and we concur, that if the power train is geared such that the engine can get up to speed and thus insure proper coolant and lubricant flow, the added weight will not affect engine performance or life.

The risk associated with using the 6V-53T engine in the SM113 vehicle upweighted to 35,000 pounds is minimal. Its design integrity and performance have been adequately demonstrated. At this stage of its life its growth potential is probably limited. But it is now operating at 300 HP in other applications. This is almost 10% more power than is required by the SM113. This engine should be adequate for the forseeable future.

The risk that the SM113 is underpowered at weights up to 35,000 pounds can be addressed through the overall mobility analysis contained in Appendix A. In general, that analysis indicates that the SM113, even at 35,000 pounds, will provide better performance than the M113A1. It

also shows that on-road acceleration of all versions of the SM113 equals or exceeds the IFV requirement of 30 MPH in 18 to 22 seconds. This is accomplished at the expense of top speed which is significantly below the IFV requirement of 40 to 45 MPH. The only significant performance risk related to the power train is that a top speed of 30 MPH will seriously degrade mission performance.

3. Transmission.

The X-200-3 transmission was first used in the 19,000 lb XM-800T ARSV where it performed creditably although some problems did develop. It was redesigned for use in a 30,000 lb vehicle and has accumulated several thousand test miles in connection with the M113A1E1 PIP. During these tests more problem areas have been discovered but these are relatively few and minor. None of these can be related to the increased vehicle weight. (Recently an M113A1E1 completed a 6000 mile test at APG without incurring a single transmission failure.) One rebuilt transmission which had over 7500 miles was disassembled to repair a malfunction in the hydrostatic steer area and showed no signs of distress in any of the bearings, gears or seals. More importantly, the clutch plates and the brake discs were in excellent condition. This last suggests that reflected loads generated by shocks to the track and sprocket are not large enough to create durability problems. As a result of recent modifications the transmission manufacturer now feels comfortable in rating the X-200-3 transmission for a 33,000 lb vehicle with a top speed of 37 miles per hour. This equates to an engine rated at 265 HP at 2550 rpm.

Like the engine, the transmission will not be adversely affected by increasing vehicle weight provided relative operating time in each gear range is not significantly changed. This can be accomplished by developing the higher torque levels required for acceptable performance through use of higher gear ratios in the final drive. Of course, the designer must insure that both components are adequately cooled.

Since the proposed SM113 does all these things, there is no reason to expect significant reductions in the generally satisfactory performance and reliability of the X-200-3 transmission.

The growth potential of this component beyond its present level appears to be minimal.

4. Final Drive.

It is accepted that the final drive will be redesigned to incorporate the higher gear ratios required by the heavier vehicles (see Table 3.1). There may ' some risk involved in this design--not so much in achieving the desireu ratio as in fitting the gear set into a housing that will not exceed the space available. This risk is minimal. The M548 final drive housing (currently installed on the stretched M113A1E1) has a ratio of 4.31:1. The highest ratio required is 5.13:1. Even if this ratio does not fit the present housing, there should be no difficulty in designing a new housing that will accommodate both the gears and the space limitation. This statement is made in full recognition of the fact that other design changes i.e. bearings, shafts, lubrication, besides gear ratio are involved. Assuming that the final drive design will continue to be a spur gear set, it may be further assumed that efficiency will remain essentially the same. But, at the higher gear ratios, higher torques will be developed in the gear set. So although the percentage of energy converted to heat will be constant, the absolute value of that heat will be higher. This situation however, does not appear to be critical. Data from Yuma testing indicates that final drive temperatures are now well below the critical values. In one run where transmission temperature was 328°F, final drive temperatures were 191° and 170° respectively. There appears to be a comfortable margin of safety-on the order of 100°. Therefore, in spite of the fact that a new final drive will be required, it appears that there is little risk that a satisfactory design can be readily achieved.

TABLE 3.1 M113 FINAL DRIVE RATIOS

VEHICLE	WEIGHT	RATIO
STD	24,600	3.93
ITV (STD)	26,000	3.84
ITV (Stretched)	29,500	3.84
TAT	31,500	4.05
BAT	33,500	4.66
TBAT	35,000	5.13
M548	26,450	4.31

5. Suspension.

a. Load Capacity.

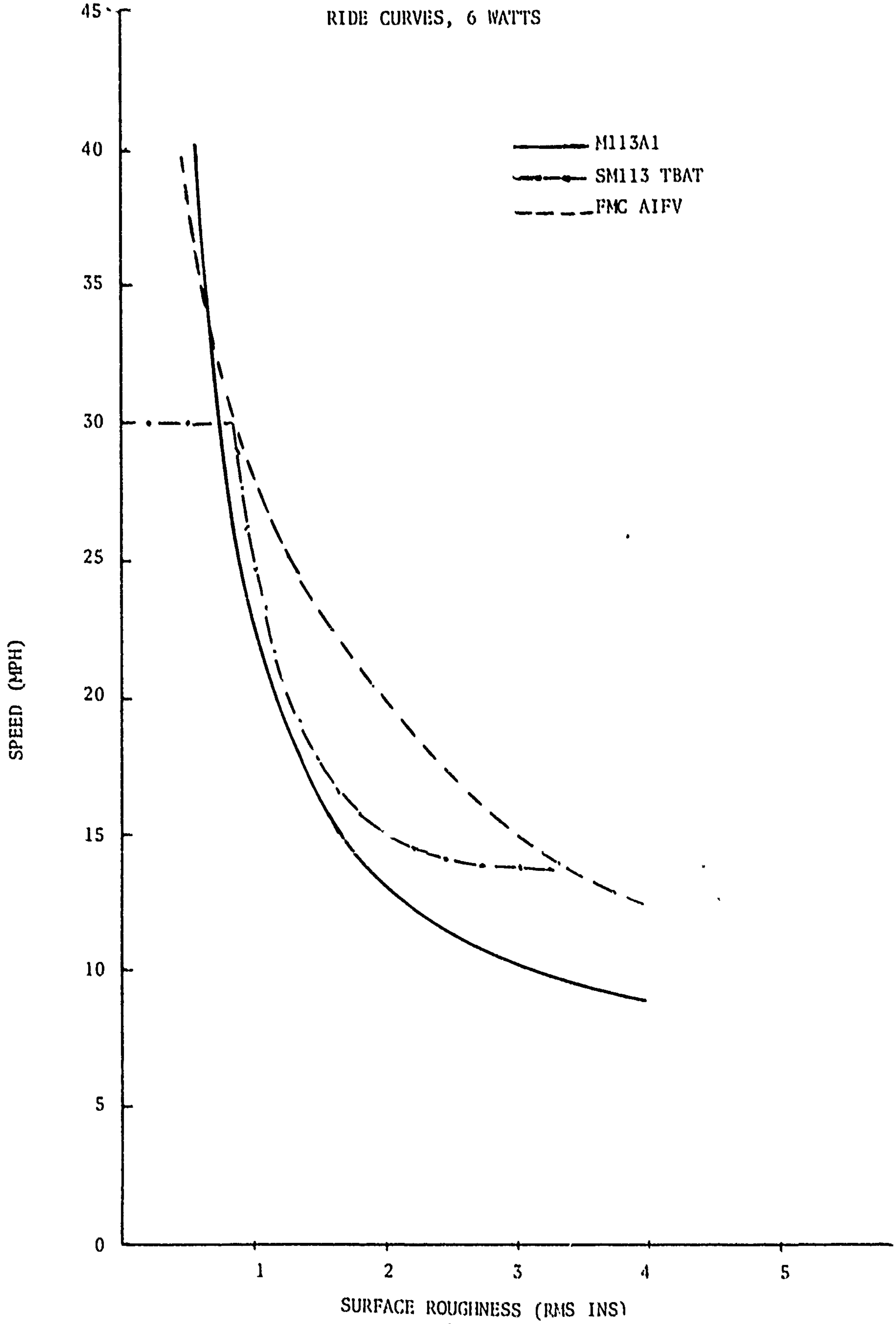
The suspension components used in the SM113 are the same as those used in the M113A1E1 which has a top test weight of 26,500 pounds. In turn, the M113A1E1 components were assembled from several sources. Those are:

COMPONENT	SOURCE	VEHICLE WEIGHT (lbs)
Torsion bars	Designed for M113A1E1	26,500
Nos. 1, 2, 5, & 6 road arms	FMC AIFV	28,000
Nos. 3 & 4 road arms	M113A1	24,600
Shock Absorbers	FMC AIFV	28,000
Bearings	M113A1	24,600
Road Wheels	M113A1	24,600

All the above vehicles have ten road wheels. The SM113 has twelve. The resulting static load percentage changes (using the above weights as a reference) for the suspension components when used on the various SM113 configurations are:

CONFIGURATION	TORSION BARS	NOS. 1, 2, 5 & 6 ROAD ARMS	ROAD WHEELS, BEARINGS NOS. 3 & 4 ROAD ARMS
ITV (29,500 lbs)	-7	-12	0
TAT (31,500 lbs)	0	- 6.5	6
BAT (33,500 lbs)	5	0	14
TBAT (35,000 lbs)	10	4	18.5

Some indication of the dynamic loads effects on the suspension elements may be gained from Figure 3.2. This figure shows the ride curves for the M113A1, the SM113 TBAT and the FMC AIFV. These curves indicate the speeds at which the vehicles can traverse terrains of various surface roughness while the driver is experiencing an average absorbed power level of six watts. At a surface roughness of three inches rms, the speed of the SM113 is 31% higher than that of the M113A1 and 8.5% lower than that of the FMC AIFV. (These differences are actually only 3.5 and 1.5 MPH respectively, however). Except for surface roughnesses of less than 0.9 inches rms, the AIFV can go faster over the same terrain,


RIDE CURVES, 6 WATTS
M113A1
SM113 TBAT
FMC AIFV
SPEED (MPH)
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
SURFACE ROUGHNESS (RMS INS)
Figure 3.2

while the SM113 can go faster than the M113A1. Generally, it would be expected that a faster vehicle would experience higher dynamic loads and that the components, designed for the AIFV would be suitable for a similar but slower vehicle. However, the SM113 TBAT is substantially heavier than the AIFV and has a significantly higher pitch moment of inertia. It is anticipated therefore that the loading of the suspension elements on the SM113 TBAT will be higher than those of the AIFV, and to a much greater degree, than those of the M113A1. The result will be a decrease in the life of any components loaded beyond the original design values.

Estimates, based on engineering judgement, indicate that the decrease in life will follow the trend of the static overloads, with an adjustment for the dynamic load contribution. The percentage life decrease estimates are given below:

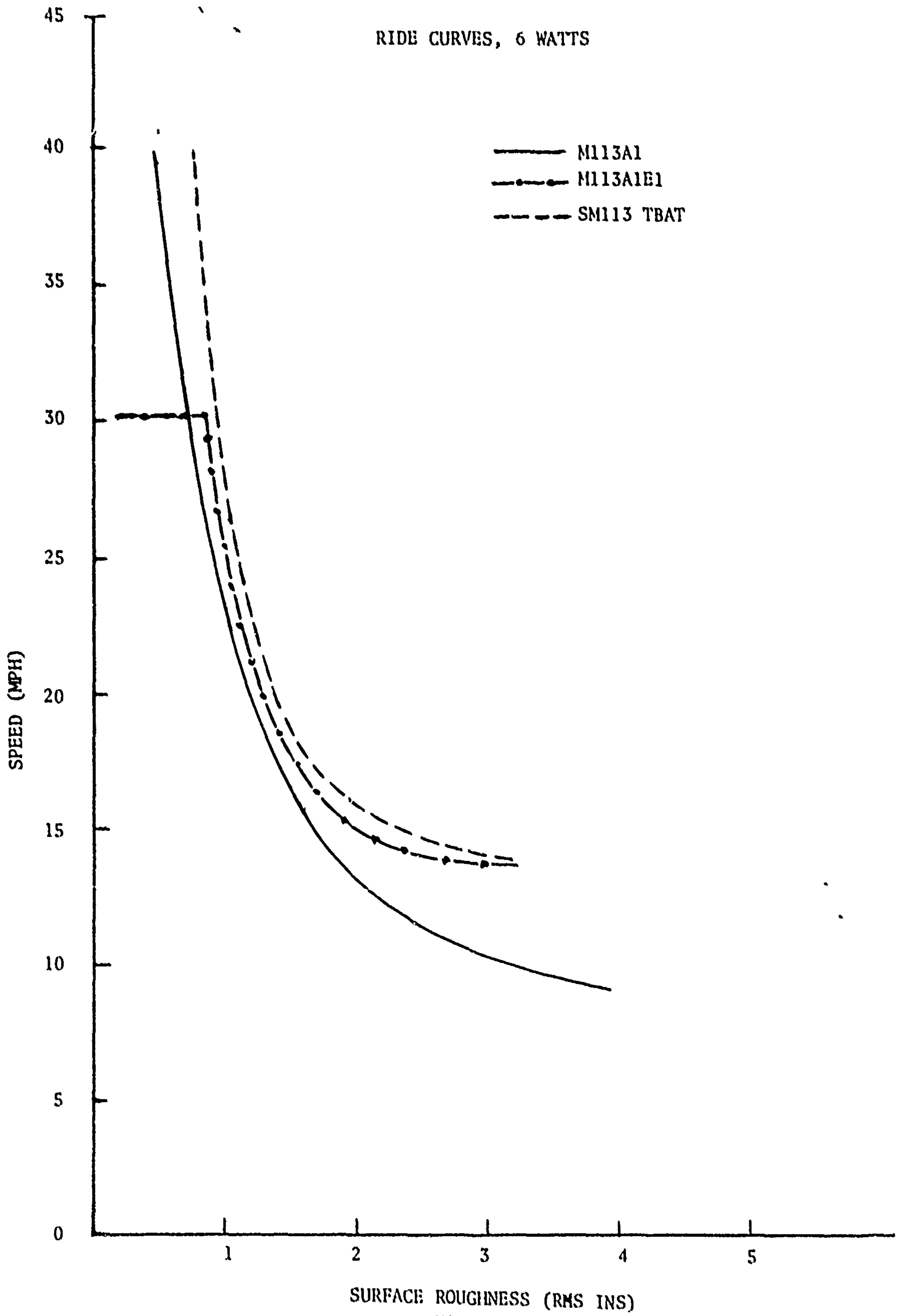
CONFIGURATION	TORSION BARS	NOS 1, 2, 5 & 6 ROAD ARMS	ROAD WHEELS, BEARINGS, NOS 3 & 4 ROAD ARMS
ITV	0	0	0
TAT	2	0	10
BAT	5	5	15
TBAT	10	10	20

The shock absorbers are not shown in the tabulation. Tests performed on the SM113 TBAT at APG on the Perryman No 3 course resulted in catastrophic failure of the shocks during speed runs. Replacement of the shocks by those of a different design is required. No other catastrophic failures or indications of such failures were noted. This indicates that only a reduction of life of the other components would be the expected result of incorporating them in the SM113 concepts.

b. Performance.

The measure of relative performance of the SM113 suspension will be the speed with which the vehicle can traverse surfaces of various roughnesses while imposing an absorbed power level of 6 watts on the driver. Figure 3.3 shows the speed versus surface roughness plots for the M113A1, the M113A1E1 and the SM113 TBAT. For the range of surface roughnesses shown, there is little degradation in suspension performance of the SM113 TBAT compared to the M113A1E1. Both are better than the M113A1, particularly on the rougher surfaces. From the data shown in Table A-1 (Appendix A), an estimate of average surface roughness in West Germany might be on the order of 1.5 inches RMS. For this roughness it is noted that the heaviest stretched configuration (35,000 lb) will be ride limited at a speed which is only 'bout one mph slower than the M113A1E1 at 26,500 lb. While this difference may be as much as two to three mph at other roughnesses, it is clear that the risk

of excessive ride performance degradation is minimal up to 35,000 pounds GVW. However, the development of a satisfactory shock absorber is required. This should be a low to medium risk effort. The life degradation of the other components is as noted.



RIDE CURVES, 6 WATTS
M113A1
M113A1E1
SM113 TBAT
45
40
35
30
25
20
15
10
5
0
SPEED (MPH)
1
2
3
4
5
SURFACE ROUGHNESS (RMS INS)

Figure 3.3

6. Track.

The SM113 program plans to use a new design double pin track to replace the single pin track used on the M113A1. A new design will allow normal design practices and margins of safety to be used, a more desirable approach than extending the capabilities of the old single pin track.

A load capacity of 70,000 pounds in tension has been incorporated in the new track. Track pins and bushings have been increased in diameter, resulting in decreased stresses when compared to those of the M113A1. A new sprocket has also been designed. This will drive the track through the end connectors and will fit the output shaft of the final drive without alteration to that component.

No new technology will be utilized in designing or producing the new track. Double pin track design has been well explored and in the case in question should pose no new problems. The new track will be heavier, adding 500 pounds to the vehicle weight. This addition has been accounted for in the concept weights. From preliminary design drawings, there appears to be a slight reduction in ground contact area of the double pin track compared to the single pin track.

A comparison of the pin section moduli and projected bushing bearing areas is shown below. The section modulus of a beam in bending, which is the way track pins are loaded, is an indication of the stress level in the beam, in this case the pin. For a given bending moment, the higher the section modulus, the lower the bending stresses.

The two tracks differ in the way the track bushings are loaded. In the double pin track, the pins are bonded directly to the bushings and the pin load is transferred directly to the bushing. In the single pin track, the pin is inserted in a metal bushing which in turn is bonded to the rubber bushing. The projected areas shown, which are an indicator of the load intensity, are in the case of the double pin track, the projected area of the pin (length X diameter) on the bushing. For the single pin track it is the steel bushing projected area.. Also shown below are the design loads of the tracks.

Track	Design Load (lbs-tension)	Section Modulus Ins^3	Projected Area On Bushing In^2
Single Pin	52,000	.0265	6.35 (center guide side) 5.45 (other side)
Double Pin	70,000	.079	10.40

The design load of the double pin track is 38 % higher than that of the single pin. Since the load distribution in the pins is different in

the two tracks, direct comparison should not be made. However, the significantly higher modulus of the double pin track pin is certainly indicative of its relatively greater strength.

Again, the 65% greater bushing bearing area of the double pin track would point to lower bearing stresses in the bushings.

The increased weight of the new track will impose slightly heavier loads on the drive train and suspension elements but these are not significant. A growth factor of about 20% is available in the new design.

When normal developmental problems are taken into account, the new track appears to be a low to medium risk item.

7. Hull.

a. Structure.

The hull structure will require reinforcement in the weapons station area. The various concepts allow 250 pounds in their weights budget to accommodate this reinforcement. A preliminary analysis based on a 15 g vertical load on the TBAT turret shows that the loading due to this weapons station can be carried by two 6 inch I beams placed transversely to the hull longitudinal axis, fore and aft of the turret. In turn, four vertical columns will transfer this load to vertical side plates of the sponson. The weight of this reinforcement is 200 pounds, and with allowance for some minor members, the 250 pound concept allowance is demonstrated to be feasible.

No additional structural problems are anticipated, but the increased loading on the hull could expose more quickly any marginal workmanship particularly in the welds.

b. Swimming.

Extending the M113A1E1 adds approximately 75 cubic feet to the total volume of the vehicle. However, if we consider the vehicle float line to be at the same front and rear hull points as the M113A1, then about 15 cubic feet of this volume lies above the water line and does not contribute to flotation. The M113A1 has 6.5 inches of freeboard in the front and 14.3 inches in the back.

The addition of the various weapons stations increases the weight of the vehicle. In the table below are shown the weight differences between the M113A1 at 24,600 and the various SM113 configurations. Also shown are the additional vehicle displaced volumes necessary to support these additional weights.

Configuration	Weight Differences (lbs)	Volume Required (ft^3)
ITV	4,900	78.6
TAT	6,900	110.5
BAT	8,900	142.8
TBAT	10,400	167

Since the volume added in extending the vehicle does not equal those required to offset the various weight additions, the vehicle will sink below the present M113A1 float line. The sinkages associated with the various concepts are:

Configuration	Sinkage Relative To M113A1 (ins)
ITV	1.85
TAT	5.04
BAT	8.3
TBAT	11

The above sinkages assume the vehicle settles to a new float line parallel to the old. It takes into account the additional displaced volume of the added section.

It appears that all configurations except the ITV will require flotation gear. An allowance of 500 pounds for this item was made in the concepts weight budget. With proper design of the flotation gear this weight allowance should be adequate.

c. External Fuel Tanks.

The DA Fire Survivability Program is planning the incorporation of external fuel tanks on M113 vehicles. Installation of external tanks on the SM113 would result in a weight increase on the order of 1000 to 1500 pounds which would have to be accommodated. Although external tanks are not currently planned for the vehicle concepts addressed herein, we think it prudent to recognize this potential growth area and to note that the improvement in crew survivability would be accompanied by some increase in technical risk in many of the areas discussed in this report.

d. Summation.

In general, there appear to be no high risk elements associated with the hull of the SM113. Reasonable growth in both increased weight and storage can be tolerated with no significant hull changes.

8. Weapons Station.

a. General.

The fundamental reason for a weapon station is to provide firepower, therefore the risk analysis of the weapon stations for the candidate vehicles will evaluate the firepower effectiveness of the various turret configurations when mounted on the respective chassis (IFV or SM113). Since the turrets are the same as far as number and types of weapons, the firepower performance of each should be the same except for factors which would restrict or enhance the effectivenss of the armament subsystems. For this reason and due to the unknown performance levels of the TBAT II, BAT II, and TAT II turrets, the assessment was made by an examination of potential differences in the effectiveness due to the different chassis upon which the weapon stations are mounted. There appear to be two basic areas of potential differences, those associated with differences in vehicle ride characteristics and those associated with the vehicle's physical characteristics.

b. Vehicle Ride Characteristics.

The effects of vehicle ride could possibly affect the fire-on-the-move capability due to vibration levels inherent in the vehicle. The exact ride characteristics of the IFV and the SM113 at the turret are not presently known. However, if the MICV and M113A1 are used as a base as well as the ride predicted at the driver's station for the extended vehicles, it would be anticipated that the SM113 would have a higher level of vibration than the IFV. However, the product improvements applied to the M113A1 and the extensive changes made to the IFV suspension may change this situation. In any event, there could be some minor risk associated with the sighting systems. The BAT II turret configuration would employ the M36 sight which has had a history of vibration problems. However considerable design effort has been expended on this sight, and vibration problems should have been overcome. Since the integrated sight being developed for the IFV/CFV is unproved, sight vibration is a potential problem area, and there could also be some risk in mounting this sight on any vehicle which would transmit high vibration levels. However, there is no reason to expect any of the proposed configuration will result in a high vibration environment, or to expect that the sight will be sensitive to vibration. It is simply pointed out that there are unknowns in this area, though the risk is believed to be low.

c. Physical Characteristics.

The second area of examination for possible risks was in the differing physical characteristics of the vehicles. The size and shape of the vehicle chassis determine the placement of the turrets on the vehicle which in turn determines the fields of fire, i.e. angles of depression and elevation, etc. In addition, placement of the weapon station and its space claim determine the remaining space available to

accommodate the squad and stowage of the required OVE. Vehicle characteristics received from TARADCOM and FVS PMO contained the angles of depression and elevation for the vehicle/turret configurations. The table below summarizes these data.

	Angles of Elevation and Depression			
	Elevation		Depression	
Vehicle/Turret	25mm	TOW	25mm	TOW
IFV/*	60°	30°	-10°	-20°
SM113/*	60°	30°	-10°	-20°
ACCV	45°	30°	-10°	--
IFV/ITV	--	38°	--	-30°
M113/ITV	--	30°	--	-31°

*TBAT, BAT, and TAT Turrets as appropriate.

It is apparent from even a cursory examination that there is no differences in any of the vehicles' firepower due to this factor. The only difference noted is in the TOW angle of elevation of the IFV using the ITV turret. The 8° advantage of the IFV in this direction would not provide an advantage in the ground-to-ground role. Only in a possible helicopter engagement would this be an advantage.

The remaining area of examination was in the space available for the squad and stowage of ammunition and their equipment. The description of the vehicles indicated the following outside dimensions:

HULL DIMENSIONS (ft)

	Length	Width	Height
IFV	30.4	9.8	5.0
SM113	18.0	8.3	4.7

The weapons station placement in the IFV is such that the difference in storage space between it and the SM113 is not as great as might be expected. There is about 20% decrease in total volume in storage space. Therefore, the stretched M113 will not accommodate all the ammunition and equipment and allow for the incorporation of firing ports (i.e. stowage will have to be accomplished in the sponsons). The extent of degradation of effectiveness has not been established, but the MN requirement for the firing port weapon could not be fulfilled. Therefore, this would have to be considered as an area of performance risk to the degree that the firing port weapon is mission essential. The other consideration, the availability of ammunition for reload, was examined from the preliminary sketches for SM113 stowage. It does not appear that TOW reload or 25mm reload would be an area of risk. This

would be a matter of establishing an operating procedure and of training. It does not appear that there would be any resultant difference in reload times for any of the armament systems.

B. INDEPENDENT RELIABILITY ASSESSMENT

1. Introduction

This study was conducted to develop RAM estimates for the SM113 vehicle with various turret configurations. The primary configurations considered in this analysis are:

Chassis	Turret
SM113	ITV
SM113	TAT
SM113	BAT
SM113	TBAT

This analysis will address automotive reliability only. Integration of the turret and vehicle was not considered in the risk assessment. The estimates presented are for a developmental test environment.

2. Approach to Analysis

The approach employed to develop the RAM estimates for the various concepts is outlined:

a. Development of a RAM baseline for the M113A1 APC and its major subassemblies. The baseline was developed using RAM data from previous testing of the M113A1. Tests included in the baseline data were: (1) M113A1 Initial Production Tests (IPT) and Inspection Comparison Tests (ICT) conducted from 1970 to 1977 and (2) M113A1 testing conducted at Fort Benning, GA during the MICV OT II.

b. The baseline RAM estimates were adjusted for the extended M113A1E1 vehicle that incorporates various Product Improvements and other changes that will be a part of the concept vehicles. In addition to the hardware changes, the effects of operating the vehicle in an IFV type mission scenario were evaluated and are reflected in the RAM estimates for the extended M113A1E1. The effects of the added weight of the weapon stations were not evaluated for this intermediate step.

c. RAM estimates of the extended M113A1E1 were adjusted to extrapolate RAM estimates for the concept with four different type turrets being considered. Engineering judgment was used to estimate the effects of added weight and complexity of the concept vehicles.

3. Baseline Data

As mentioned in the preceding paragraph, M113A1 testing included in the RAM baseline estimates were: (a) M113A1 IPT and ICT testing and (b) testing of the M113A1 during the MICV OT II. A total of eight M113A1's were evaluated during the IPT and ICT testing of the vehicle from 1970 and 1977. Four Inspection Comparison Tests included

in the baseline data were new vehicles tested for about 2,000 miles each. These tests are not considered to be rigorous RAM tests for the vehicle. Any associated RAM values for the ICT should be considered as optimum estimates. The IPT testing consisted of evaluating two new vehicles for approximately 5,000 miles each. Total test miles for the IPT and ICT testing was 32,235. Ninety percent of the mileage for the IPT and ICT was conducted at Yuma Proving Ground. Therefore, the data reflect a controlled type test environment and do not reflect a variety of use conditions.

Four M113A1's were run "side by side" with the MICV's during an OT II. The mission scenario was that of the MICV and the four M113A1's were tested for a total of 7,241 miles. The M113A1's taking part in the MICV OT II were selected from a large pool of vehicles based on a review of each vehicle's maintenance log and interviews with maintenance personnel. Six vehicles were selected for testing from those determined to be acceptable. Conditioning for test consisted of submitting the vehicles to Q-service prior to start of the OT II. Quality of the vehicles prior to test was therefore questionable, and one of the test vehicles was an overhauled vehicle.

All test incidents occurring during the testing were recorded by Equipment Performance Report (EPR) or by Operational Test Incident Report (OTIR). Each of the test incidents was scored by a formal scoring conference against the Failure Definition and Scoring Criteria (FD/SC) as outlined in AR 702-3. The M113A1 FD/SC was used to evaluate the IPT and ICT and the MICV FD/SC was used to evaluate testing during the MICV OT II. There is little difference between the M113A1 and the MICV FD/SC's when evaluating the automotive subassemblies. The results of the scoring conferences were used to compute the baseline RAM estimates.

TABLE 3.1

SUBSYSTEM MEAN MILES BETWEEN FAILURE (MMBF)

Std. Gov't Group	Subsystem	MICV OT II M113A1 Test	M113A1 IPT, ICT Test	Combined Test Data		Extended M113A1E1 Adjusted Baseline
01	Engine	3,620	16,118	9,869		8,000
03	Fuel/Air Induction	2,896	12,894	7,895		7,895
05	Cooling	7,241	21,490	15,790		15,790
06	Electrical	2,896	10,745	7,177		6,818
07	Transmission	7,241	9,210	8,772		5,000
08	Transfer & Final Drives	——	10,745	13,159		11,844
09	Prop Shafts/U-Joints	7,241	16,118	13,159		11,844
1303	Idler	——	12,894	15,790		
1305	Track	1,448	——	7,895	2,820	1,900
1311	Roadwheel	1,317	——	7,177		
13	Torsion Bars, Sprockets, etc.	7,241	——	39,476		
14	Steering	14,482	32,235	26,317		20,000
16	Shock Absorbers	——	——	39,476		39,476
18	Hull	7,241	6,447	6,579		6,579
	TOTAL	315	1,240	806		631

Assessed mission failures were grouped by Standard Government Group numbers and reliability estimates (MMBF) of the subsystems were computed by dividing total test mileage for each subsystem by the total number of combat mission failures assessed for that particular subsystem. Results of the baseline evaluation are presented in Table 3.1. Also presented in this table are the adjusted baseline estimates for the various subsystems. The adjusted estimates take into consideration the effects of hardware changes incorporated in the extended M113A1E1 and also the effects of operating the extended M113A1E1 in an IFV type of environment as opposed to a controlled proving ground type of environment.

4. Analysis of Alternatives

It is believed that the following subsystems are not affected by the increased weight and/or complexity of the alternative concept vehicles:

- o Fuel/Air Induction
- o Cooling
- o Steering
- o Shock Absorbers (see paragraph 4.f)
- o Hull

Failure rates for the remaining subsystems were adjusted from the baseline failure rates because of either added weight or complexity. Each of these subsystems are discussed below:

a. Engine.

The 6V53 engine used in the M113A1 will be replaced by the 6V53T in the SM113 vehicles. The failure rate for the engine subsystem was adjusted for the SM113 in our RAM analysis. The majority of our test data for the 6V53 engine was from 2,000 mile tests of the M113A1. The failure rate for the engine would be expected to increase as engine usage is increased. Therefore, the MMBF for the engine was adjusted to assume a 6,000 mile test cycle for the engine.

One of the major failure modes for the 6V53 engine in the past has been overheating. The improved cooling system should diminish the number of failures due to overheating.

The increased weight of the concept vehicles should not require the engine to develop higher outputs. The increased torque requirements of the vehicle will be obtained by increasing the final drive ratio.

Failure rates for the engine subsystem of the concept vehicles were adjusted for the IFV type mission scenario in which the

vehicles will be employed. The testing of the M113A1 vehicle did not expose the engine to this type of performance requirement.

b. Electrical

The SM113 will be serviced by a higher capacity alternator and two additional batteries. The weapon station of the concept vehicles will put an increased demand on the electrical system. The electrical demand of the TAT, BAT, and TBAT concepts should be similar, while the demand of the ITV concept will be somewhat less than the TBAT's. Degradation of the electrical system was adjusted proportionately to the increased demand of the weapon station. Also taken into consideration was the affect of vibration of the upweighted vehicles on the electrical systems.

c. Transmission

The X-200 transmission has undergone previous testing during the SCOUT development program. During this testing program the X-200 transmission demonstrated an MMBF of 4,230 during 33,000 miles of testing in an 18,000 lb GVW vehicle with a top speed of 50 mph. Assuming a reasonable amount of reliability growth and design maturity, a MMBF of 5,000 is being projected for the extended M113A1E1 version of the X-200 transmission. The X-200 transmission has experienced three combat mission failures during the M113A1E1 testing program.

The transmission performance should not be adversely affected by upweighting the vehicle for the proposed concepts. The higher torque levels required for acceptable performance can be generated through the use of higher grear ratios in the final drive.

Since the transmission includes the braking function and performs the steering function, upweighting the vehicle should have a degrading effect on transmission reliability. Failure rates were adjusted for the transmission to take into consideration the fact that the X-200 transmission will be utilized to stop, steer, and control a heavier vehicle.

d. Final Drives

The final drives will be redesigned to incorporate the higher gear ratios required by the heavier vehicles. Higher torques will be developed in the gear set resulting in a heavier duty cycle. This should produce a small increase in the failure rate. Thus, a decrease of about 15% in RAM will be assumed for the heaviest vehicle (TBAT weapon station). MMBF values will be adjusted for the remaining concept vehicles on a basis of weight increase over the extended M113A1E1 vehicle as a baseline.

Another factor taken into consideration for evaluating failure rates of the final drive is the effect of shock from more frequent

ground impacts. The heavier vehicles are expected to place a more severe and frequent impact load on the final drives and the idler assembly, especially when operating in rough terrain.

e. Prop Shafts/U-Joints

An increase in the failure rate of the prop shafts and U-joints is assumed, due primarily to the increase in vehicle weight. A degradation of 5% will be assumed for the RAM levels of the heaviest vehicle. MMBF values will be adjusted for the remaining concept vehicles on a basis of weight increase over the extended M113A1E1 vehicle.

The failure rate of the extended M113A1E1 vehicle was initially increased when compared to the demonstrated RAM levels of the M113A1 to adjust for the expected mission scenario of the M113A1E1. Data for the M113A1 reflects vehicles tested for 2,000 miles. Failure rates are expected to increase as the length of the test increases.

f. Suspension

MMBF levels of the suspension components were degraded in proportion to the increase in vehicle weight. The degradation factors were applied in assessing the idler assembly, track, roadwheels, torsion bars, drive sprockets, etc., as a combined subsystem.

Initially, the failure rate for the suspension subsystem was adjusted for the extended M113A1E1 in our RAM analysis. The majority of our test data for suspension components were based on various 2,000 mile tests of the M113A1. The failure rates for suspension components would be expected to increase as usage is increased. Therefore, the MMBF for the suspension subsystem was adjusted to assume a 6,000 mile test cycle for these components.

A new design double pin track on the SM113 vehicles will replace the single pin track used on the M113A1. The new double pin track is heavier than the single pin track, and, therefore, will impose heavier loads on the drive train and other suspension components.

The suspension components of SM113 are the same components used on the M113A1E1, which has a GVW of 26,500 lbs. Static loading on the suspension components is increased for the heaviest vehicle. The increased failure rate is expected to be proportional to the static overloading condition of the components. The effect of dynamic loading was also assessed. The loading of SM113 TBAT will be higher than the original design values. These conditions will contribute to the increased failure rates for the suspension components.

Shock absorbers used on the M113A1E1 during testing at APG have experienced catastrophic failures. A newly designed shock absorber will be needed for SM113 vehicles. The failure rates for the shock absorbers

TABLE 3.2

MMBF ESTIMATES FOR CONCEPT VEHICLES

Std. Gov't Group	Subsystem	Extended M113A1E1	SM113 w/ITV	SM113 w/TAT	SM113 w/BAT	SM113 w/TBAT
01	Engine	8,000	7,200	6,880	6,640	6,400
03	Fuel/Air Induction	7,895	7,895	7,895	7,895	7,895
05	Cooling	15,790	15,790	15,790	15,790	15,790
06	Electrical	6,818	6,500	6,000	6,000	6,000
07	Transmission	5,000	4,750	4,650	4,575	4,500
08	Final Drive	11,844	10,920	10,554	10,280	10,000
09	Prop Shafts & U-Joints	11,844	11,550	11,425	11,335	11,250
1303 1305 1311 13	Idler Track Roadwheels Torsion Bars, Sprockets, etc.	1,900	1,650	1,550	1,475	1,400
14	Steering	20,000	20,000	20,000	20,000	20,000
16	Shock Absorbers	39,476	39,476	39,476	39,476	39,476
18	Hull	6,579	6,579	6,579	6,579	6,579
	OVERALL SYSTEM	631	587	564	551	536

were not degraded in this RAM analysis. Even though the replacement rate for shock absorbers would increase, a mission failure is not assessed unless all six shock absorbers would be replaced on the vehicle. However, the design problem for the shock absorbers must be addressed to preclude further degradation to other suspension components.

5. MMBF Estimates for Concept Vehicles

The results of this RAM analysis, by subsystem and total system, are presented in Table 3.3. These estimates are based on the assumption that an adequate test and development program will be conducted.

6. Mission Reliability

Given the MMBF values for each of the four concept vehicles as presented in Table 3.3, the following represents the probability of each concept vehicle completing a 50-mile mission.

Vehicle	Probability of Completing 50-Mile Mission
Extended M113A1E1	0.92
SM113 w/ITV	0.92
SM113 w/TAT	0.92
SM113 w/BAT	0.91
SM113 w/TBAT	0.91

7. MMBF Estimates with Scheduling Considerations

As stated in paragraph B.5, the MMBF estimates presented in Table 3.3 were based on the assumption that an adequate test and development program would be conducted. This would allow adequate time for hardware redesign of unreliable components for other improvement efforts to be implemented during the testing and development program.

Under tasking from the IFV/CFV Special Study Group, AMSAA was asked to assess the impact of the proposed test and development schedule of the SM113 (Table 3.4) on the attainment of the RAM estimates for the concept vehicles. Each subsystem listed in Table 3.3 was reassessed, and reliability estimates were developed taking into consideration the constraints posed by the fixed test schedule. The proposed test schedule allows for adequate testing in terms of numbers of miles the vehicles will be tested. However, little time is allowed for component redesign and testing of the redesign if a component exhibits a design deficiency during the testing cycle. This would adversely affect the attainment of the reliability estimates presented in Table 3.3. Table 3.5 presents reliability estimates for each concept vehicle to include scheduling considerations.

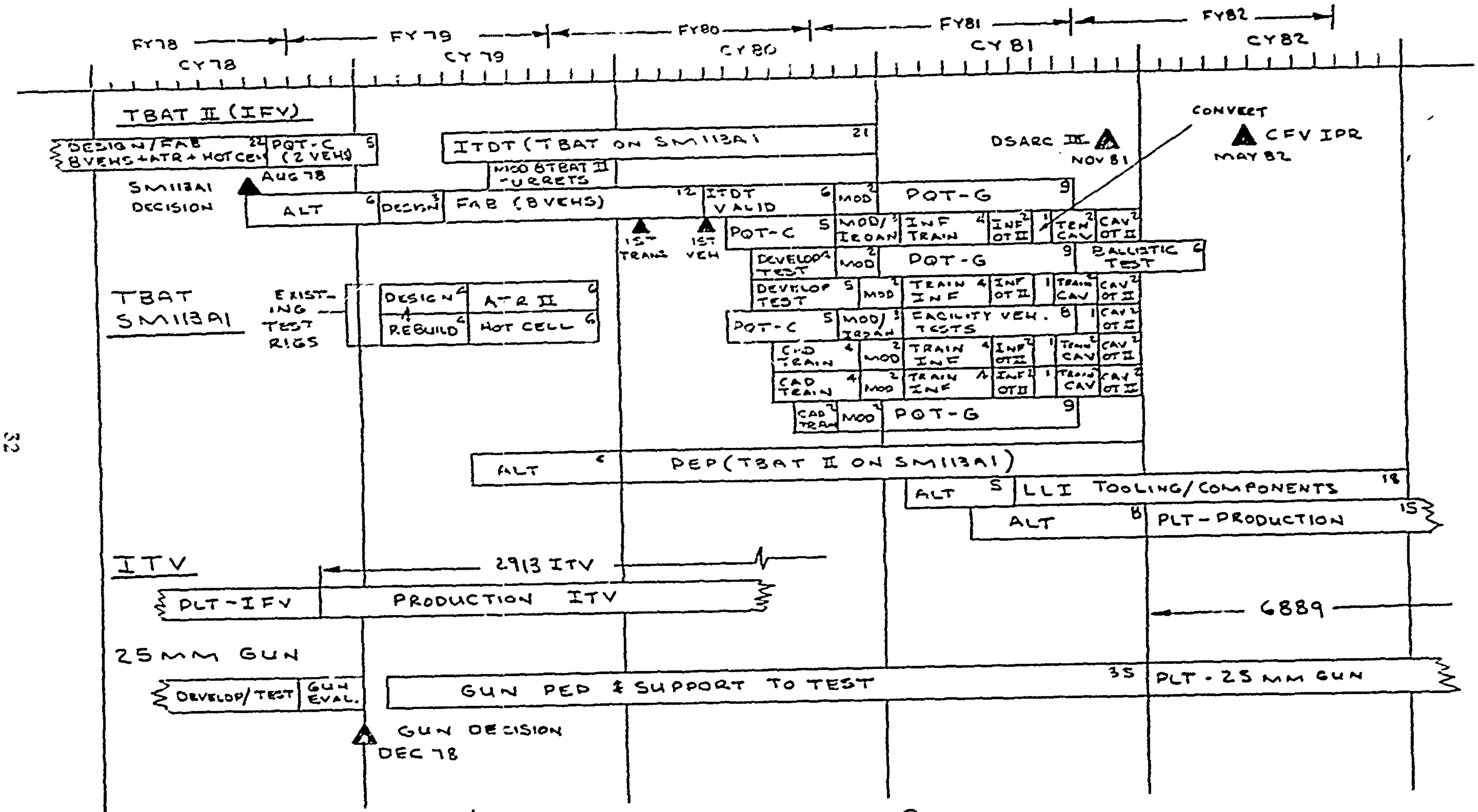


TABLE 3.3 DEVELOPMENT SCHEDULE FOR SM113A1

TABLE 3.4

MMBF ESTIMATES WITH SCHEDULING CONSIDERATIONS

Std. Gov't Group	Subsystem	Extended M113A1E1	SM113 w/ITV	SM113 w/TAT	SM113 w/BAT	SM113 w/TBAT
01	Engine	7,500	6,800	6,500	6,200	6,000
03	Fuel/Air Induction	7,895	7,895	7,895	7,895	7,895
05	Cooling	15,000	15,000	15,000	15,000	15,000
06	Electrical	6,818	6,200	5,400	5,400	5,400
07	Transmission	4,600	4,320	4,200	4,080	4,000
08	Final Drive	11,844	9,282	8,443	7,710	7,000
09	Prop Shafts & U-Joints	11,844	11,210	10,960	10,690	10,500
1303	Idler	1,800	1,450	1,305	1,155	1,050
1305	Track					
1311	Roadwheels					
13	Torsion Bars, Sprockets, etc.					
14	Steering	20,000	20,000	20,000	20,000	20,000
16	Shock Absorbers	39,476	39,476	39,476	39,476	39,476
18	Hull	6,579	6,579	6,579	6,579	6,579
	OVERALL SYSTEM	610	540	510	475	450

IV. COMPARISON WITH BATTELLE ANALYSIS

Battelle Columbus Laboratories conducted an Infantry Fighting Vehicle Concept Evaluation Study for the IFV Task Force, which contained a risk assessment of a generic M113A1E1 (extended) and an IFV/CFV-TBAT-II, among others. A draft of the Risk Assessment Attachment to the Battelle report has been reviewed, at the request of the SSG, and the following comments are provided regarding the methodology of that study vis a vis that utilized in this report.

A. Methodology

The Battelle report assesses technical risk in terms of the probability of achieving planned schedules and cost; and as such addresses program risk rather than the pure technical risk that a specific design will be successful, given a vaguely defined test and development program. The AMSAA evaluation addresses the latter, excluding cost and schedule. The Battelle report indicates that its findings, i.e. achievement probabilities, are not absolute; but rather, provide a comparison for rank ordering among the programs for ability to meet planned objectives. However, the basis for the authors' opinion that certain program elements contain potential engineering problems which might result in schedule delays is in no sense provided. In the absence of such rationale it is difficult, if not impossible, to compare the risks for concepts in this report with those discussed in the Battelle report.

It is noted that the M113A1E1 (extended) is treated generically in the Battelle report in that one analysis applies to all vehicle weights from 28,000 to 34,000 lbs without addressing variation in risk as the weight increased. It becomes apparent then, that the level of detail considered by Battelle was significantly less than that in this report.

The Battelle report concluded that the M113A1E1 (extended) program represents a medium low risk. Nothing was discovered in the AMSAA analyses that would refute that conclusion. Battelle also found the IFV/CFV-TBAT-II program to represent a medium low risk. AMSAA, by direction, did not address the risk with the IFV other than for the candidate turrets. Nevertheless, from prior association with the IFV program as the independent evaluator, we are inclined to agree with the Battelle assessment; that at the current stages of the respective programs the technical risk levels of the IFV and the SM113 do not differ significantly.

B. Relative Complexity of the SM113 and the IFV

In response to a request from the SSG for comment on the relative complexity of the SM113 and the IFV, the following is offered. The primary source for complexity concerns in combat vehicles is normally the turret and associated weapons, sights and fire control. However, for purposes of this report, the weapons stations are common to both vehicles, so they do not enter into the comparison. Having reduced the area of

consideration to the automotive chassis, one can simply compare each of the principal automotive components as the basis for assessing relative complexity. In doing so, one finds that fundamental differences are for the most part nonexistent. The diesel engines, hydrostatic steer, torsion bar suspension, shock absorbers and track are all similar in type in the two vehicles, though scaled upward somewhat in capacity for the larger IFV. The IFV does have return rollers rather than the flat track of the M113, but this makes no contribution to complexity. The only significant difference between the vehicles is in transmission type. The GE HMPT-500 hydromechanical transmission in the IFV might be considered slightly more complex than the Allison X-200-3 in the SM113, if only because maintenance personnel are more familiar with hydrokinetic transmissions. However, the fundamental design concept of the hydromechanical transmission is considered by many to be less complex. From the operators point of view, it is expected that the hydromechanical design is less demanding, in that test drivers have found it smoother in shifting and steering, though not as smooth on initial take off. The danger of transmission overheat in attempting to move a stalled vehicle is also largely overcome with the hydromechanical design. So insofar as the operator is concerned, the IFV transmission is less complex.

Overall, the assessment here is that any complexity increases in the IFV due to higher performance components are compensated for by maintainability considerations in initial design, so that there is no significant difference in complexity between the IFV and the SM113.

V. SUMMARY RISK ASSESSMENT

A. Components.

The principal components of the SM113 have been evaluated individually and as an integrated automotive platform in terms of the risk that they would be contributors toward an unsatisfactory vehicle design. The findings are summarized in Table 5.1.

The structural integrity of all components was found to be satisfactory. It is believed that the vehicle configuration (component selection) is fundamentally sound for gross vehicle weights up to 35,000 pounds. The risk that any of the principal components is significantly undersized and thus of questionable structural integrity is judged to be low.

The risk of unsatisfactory performance is addressed by recognizing at the outset that the IFV/CFV will be utilized for a variety of missions over a broad spectrum of environmental conditions. The risk that any specific level of performance capability is unsatisfactory is dependent upon the frequency distributions for missions and terrain conditions. While these distributions are not well defined, we do know that the Army has judged the M113A1 performance to be unsatisfactory since increased performance was required in MICV. Further, MICV automotive performance requirements express a performance level for which the Army believes the risk is acceptably low that mission demands will be met. Performance risk can be addressed, then, by comparing performance of the SM113 configurations with that of the M113A1 and the MICV MN requirements. Appendix "A" provides data for such comparisons, although all MN requirements are not examined. Based on this, the power train components (engine, transmission and final drive) are rated together as increasing from low performance risk in the ITV vehicle which approximates the IFV in mobility performance to medium high risk in the TBAT configuration, which is only a slightly better performer than the M113A1. Acceleration of all stretched versions is found to be adequate. The principal contribution to risk is from the significant reduction in top speed of the heavier vehicles. The cooling system has a medium risk that its performance will be unsatisfactory for all configurations. This assessment is based on the fact that all configurations will cool at a tractive effort to weight ratio of .49 at 115°F ambient. The M113A1 cooling level involved high risk at a TE/W of about .35, thus necessitating a cooling PIP. The ECP-70 cooling at a TE/W of about .53 must have involved at least medium risk since it was not deemed satisfactory for the PIP. Hence the medium risk assessment for the SM113 cooling. The suspension and track provide performance at a level that has low risk of negative impact on mission accomplishment. The hull is assigned a low to medium performance risk because it will not accommodate the firing port weapon required for MICV.

The general impression regarding growth potential is that the automotive components are approaching the upper end of design applicability

TABLE 5.1 SM113 Component Risk Summary

	STRUCTURAL INTEGRITY				PERFORMANCE				GROWTH POTENTIAL			
	ITV	TAT	BAT	TEAT	ITV	TAT	BAT	TBAT	ITV	TAT	BAT	TBAT
Engine	L	L	L	L					L	L-M	M	H
Transmission	L	L	L	L	L	L-M	M	M-H	L	L-M	M	H
Final Drive	L	L	L	L					H	H	H	H
Cooling	L	L	L	L	M	M	M	M	L	L-M	M	H
Suspension	L	L	L	L	L	L	L	L	L	L-M	M	H
Track	L	L	L	L	L	L	L	L	L	L	L-M	M
Hull	L	L	L	L	L-M	L-M	L-H	L-M	L	L	L	L

L - Low Risk　　M - Medium Risk　　H - High Risk

in a 35,000 pound vehicle. Some extension is theoretically possible, but at the expense of further performance limitation which is believed to be unacceptable. Therefore, the engine, transmission, cooling system and suspension are found to have high risk that significant growth potential remains in the TBAT vehicle. This risk diminishes uniformly to a low rating for the ITV configuration. For the final drive, there is essentially no growth available in any of the configurations, hence a high risk rating is given. This is keeping with the design philosophy of changing the final drive in each vehicle as a means of insuring adequate performance of other components. The track is being designed for 35,000 pounds, and so it should have some growth potential. Structural reinforcement should always be possible to extend the hull beyond the TBAT weight, so the potential is high and the risk low if growth is required.

B. Weapons Station.

To the extent that weapons station integration could be addressed with the limited information available, it is believed that there is low risk involved in coupling any of the candidate stations with either the SM113 or the IFV. It is belived there is little difference between the vehicles in terms of vibrations at the turret, fields of fire, and ammunition reload. Given that firing ports are not in the SM113 configurations, the net space available for crew and storage is also not greatly different.

C Reliability Considerations.

The current IFV/CFV mobility subsystem reliability goal for IPT is 750 MMBF. The AMSAA estimate for the M113A1 on a comparable basis is 806 MMBF. Obviously then, some trade off of reliability is necessary and acceptable for increased capability (weight and performance). Following the concept developed in Section V.A, the IFV/CFV realibility goal is held to represent a low risk level of performance; i.e. a vehicle demonstrating that reliability under test conditions will have a low risk of unacceptable reliability over the broad spectrum of field conditions. Recognizing that the SM113 configurations offer less in performance improvement over the M113A1 than does the IFV, so that less is obtained when reliability is traded off, the risk ratings shown in the following table are assigned. The primary consideration in developing these ratings was that the drop from 806 MMBF for the M113A1 to 750 MMBF for the IFV was acceptable, i.e. low risk. Increased risk is thus encountered as the reliability estimate drops below 750 miles.

		IFV	SM113			
	M113A1	GOAL	IFV	TAT	BAT	TBAT
MMBF	806	750	587	564	551	536
RISK			H	H	H	H

(Note: The DT II/OT II automotive reliability for MICV was 515 MMBF.) It is obvious then, that the reduced reliabilities expected under a compressed development scheduled (Section III.B.7) would also involve high risk.

D. Conclusion.

The level of technical risk involved in developing and fielding an SM113 up to a GVW of 30,000 pounds is not excessive, and such a program is considered feasible if cost and scheduling are favorable. Even at this weight there is substantial risk of inadequate reliability if 750 MMBF is the low risk baseline.

As the GVW increases to 35,000 pounds, additional risk is encountered in high speed performance, cooling, and particularly, in growth potential.

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APPENDIX A

MOBILITY COMPARISONS

I. GENERAL APPROACH

The overall mobility of the various stretched M113A1 configurations were evaluated by mobility modeling. The mobility performance characteristics predicted included the following:

a. Actual and average cross country speeds in selected West Germany and Jordan terrains.

b. Factors controlling vehicle speed and causing no-go conditions.

c. Speeds on fine grain soil slopes.

d. Acceleration performance on fine grain soil slopes when crossing gaps of 100 and 200 meters in length.

e. On-road speeds on selected road/trail networks in West Germany and Yuma, Arizona.

f. The one/fifty pass soil strength requirements for the stretched M113A1 equipped with 15" and 17" wide tracks and various IFV combat weight configurations.

The methodologies used to develop these predicted values of overall mobility were the Army Mobility Model, the AMSAA Acceleration Model, and the US Army Engineer Waterways Experiment Station (WES) on Road Vehicle Performance Model (VRCAMS). The cross country terrain conditions considered are those developed by WES for the locations shown in figure A-1. The range and distribution of several terrain factors occurring in these two locations are shown in table A-1.

The vehicle characteristics data used were provided by the IFV PMO, the M113A1 PMO and the FMC Corp. The general mobility characteristics of the vehicle configurations evaluated are shown in table A-2. For baseline and comparison purposes, predictions were also made for a standard M113A1, a M113A1E1(PI) configured as an ITV, and two configurations of the IFV, XM723. The data used for the XM723 vehicles reflects the power train and suspension changes made by the FMC Corp since DT II testing of the XM723, during the period August 1976 through March 1977.

The predicted on-road vehicle averag speeds reflects performance over the following distribution of road types:

AREA	CLASS 1 PAVED ROADS	CLASS 2 SECONDARY ROADS	CLASS 3 TRAILS
West Germany	104 miles	82 miles	589 miles
Yuma	84 miles	87 miles	204 miles

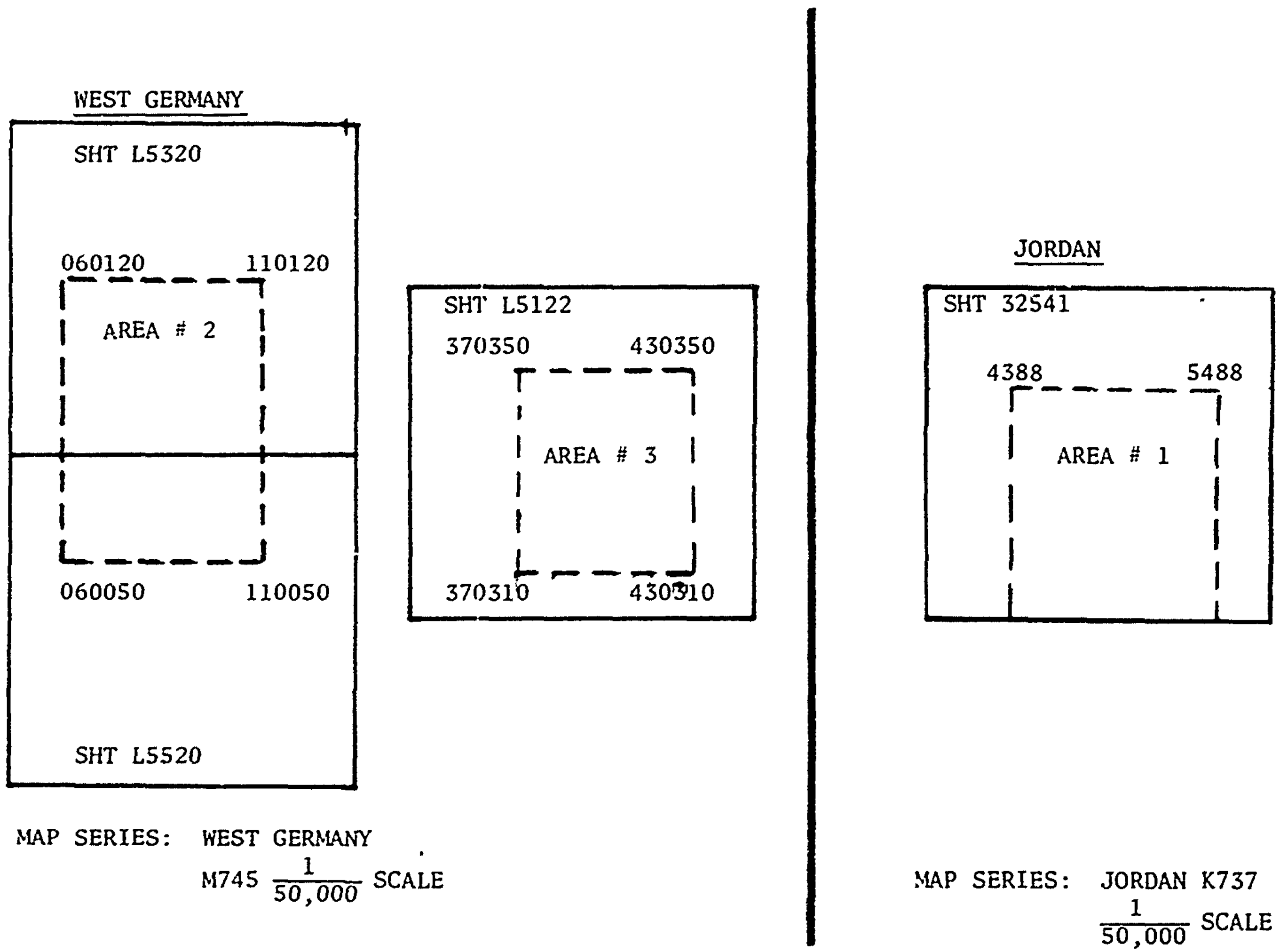


FIGURE A-1 TERRAIN AREA LOCATIONS USED IN THE STRETCHED M113A1 RISK ANALYSIS

TABLE A-1 DISTRIBUTION OF TERRAIN FACTORS

Terrain Factor	West Germany Area #2	West Germany Area #3	Jordan Area #1
Soil Type			
Fine Grain	100%Δ	100%Δ	94.6%Δ
Course Grain	—	—	5.4
Wet Season Soil Strength, (RCI, CI)			
>281	2.7	7.6	2.3
101-160	18.6	30.7	5.4 (CI)
61-100	78.0	—	92.3
41-60	.7	61.8	—
Slope, %			
0- 2	4.6	7.6	98.2
2.1- 5	9.9	6.8	1.6
5.1-10	62.0	41.9	—
10 1-20	23.4	36.9	—
>20	—	6.8	—
Surface Roughness, RMS inches			
0- .6	2.7	7.6	2.5
.61- .8	13.8	11.4	9.7
.81-1.2	5.6	12.1	10.2
1.21-1.6	45.7	18.3	27.0
1.61-2.2	12.3	33.3	24.2
2.21-3.2	11.0	11.2	9.5
>3.21	8.9	6.0	16.9
Obstacle Vertical Height, inches			
0-10	85.1	67.3	30.8
10.1-18	7.8	18.1	29.9
18.1-23.6	.5	1.8	22.8
23.7-33.5	3.3	7.5	14.3
>33.5	3.4	—	2.2

Δ - Percent of Area.

TABLE A-2 MOBILITY CHARACTERISTICS OF VEHICLE CONFIGURATIONS

CHARACTERISTICS	SM113 TBAT	SM113 BAT	SM113 TAT	SM113 ITV	M113A1E1 ITV	XM723 ITV	M113A1	XM723 IFV, TBAT
Gross Vehicle Weight, Lbs	35,000	33,500	31,500	29,500	26,000	41,900	24,600	47,000
Length, Inches	216	216	216	216	192	248	192	248
Width, Inches	113	113	113	113	105	127 3/4	105	127 3/4
Height, Inches (Top of Wpns Sta)	102	102	102	127	132	138	98 1/4	103
Min Ground Clearance	17	17	17	17	17	17.1	16	17.1
Nominal Ground Pressure, PSI	8.9	8.5	8.0	7.5	8.2	6.6	7.8	7.5
Road Wheel Travel From Static, Inches	9	9	9	9	9	14	6	14
Approach ∠, degrees	74	74	74	74	70	90	70	90
Departure ∠, degrees	38	38	38	38	40	70	40	70
HP/TON	16.3	17.0	18.1	19.3	21.9	24.1	17.4	21.3
Fine Grain Soil Trafficability VCI_1	19	18	17	16	18	12	17	13
VCI_{50}	44	42	41	39	41	30	39	32
Max Vehicle Speed, MPH	30	33	38	40	40	41	42	41
Vehicle Final Drive Ratio	5.13	4.66	4.05	3.84	3.84	4.96	3.93	4.96

The predicted vehicle on-road speeds are based only on consideration of the vehicle's power, traction, ride and stability (sliding and tipping).

Performance predictions for the XM1 and the M60A1 vehicles are also provided in this appendix as a basis for comparison with the infantry and cavalry vehicle alternatives.

II. RESULTS

A. Cross Country Mobility

The vehicle cross country speed predictions obtained from the Army Mobility Model are summarized in tables A-3 and A-4. The cumulative average speeds shown in table A-3 are vehicle average speeds over the easiest fifty (V_{50}) and ninety (V_{90}) percent of the terrain in each area. These two measures of speed are typically used to compare vehicle cross country mobility on an overall basis. These specific values are selected from vehicle speed profiles generated by first ordering the terrain units in an area according to trafficability, with terrain units in which the vehicle attains the greatest speed considered first. By cumulating the areas of terrain units in trafficability order, and keeping a running average of the vehicle speed as each unit is added, the vehicle speed profiles are generated. Figures A-2 through A-7 show these profiles for the various M113A1 and IFV vehicle configurations.

The average speeds predicted for the SM113 vehicles primarily show the effects of vehicle gross weight and final drive gearing since all other characteristics are the same. The TBAT configuration shows the lowest average speeds and is the heaviest vehicle, geared for the lowest top speed. The ITV stretched configuration shows the best average speed performance and is the lightest weight configuration and geared for the highest top speed. The M113A1E1 vehicle, a standard M113A1 equipped with a product improved power train, suspension and cooling shows faster speeds than any of the stretched vehicles, primarily due to its lighter weight.

In comparison to the standard M113A1, all the stretched vehicles show faster average speeds. The IFV configurations examined are both predicted to have average speeds equal to or greater than all the stretched vehicle configurations.

The M113A1E1, ITV vehicle is predicted to have average speeds essentially equal to those predicted for the IFV configurations.

Similar average speed predictions for the XM-1 and M60A1 are as follows:

	WEST GERMANY			JORDAN		
VEHICLE	V_{50}, mph	V_{90}, mph	PERCENT NO GO	V_{50}, mph	V_{90}, mph	PERCENT NO GO
XM-1	24.7	16.0	2.4	24.5	14.2	-
M60A1	14.3	9.4	7.7	15.1	9.5	9.6

Except for the more difficult terrain in Jordan (V_{90}) the SM113 configurations all have predicted higher average speeds than the current

TABLE A-3 PREDICTED CUMULATIVE AVERAGE SPEEDS

VEHICLE	WEST GERMANY AREAS			JORDAN AREA		
	V_{50}, MPH	V_{90}, MPH	PERCENT NO GO*	V_{50}, MPH	V_{90}, MPH	PERCENT NO GO*
M113A1	17.0	10.5	5.2	15.6	3.1	9.9
IFV, TBAT	22.9	15.4	1.9	20.0	5.9	0.1
SM113, TBAT	18.0	10.8	5.3	17.1	4.9	1.6
SM113, BAT	18.6	11.1	5.7	17.2	4.9	1.6
SM113, TAT	19.3	11.4	5.7	17.3	4.9	1.6
SM113, ITV	20.2	11.8	5.7	17.5	4.9	1.6
M113A1E1, ITV	22.0	13.4	5.6	19.1	6.1	9.8
IFV, ITV	24.2	16.0	1.7	20.0	5.9	0.1

SOURCE: Army Mobility Model

* Percent of Total Area

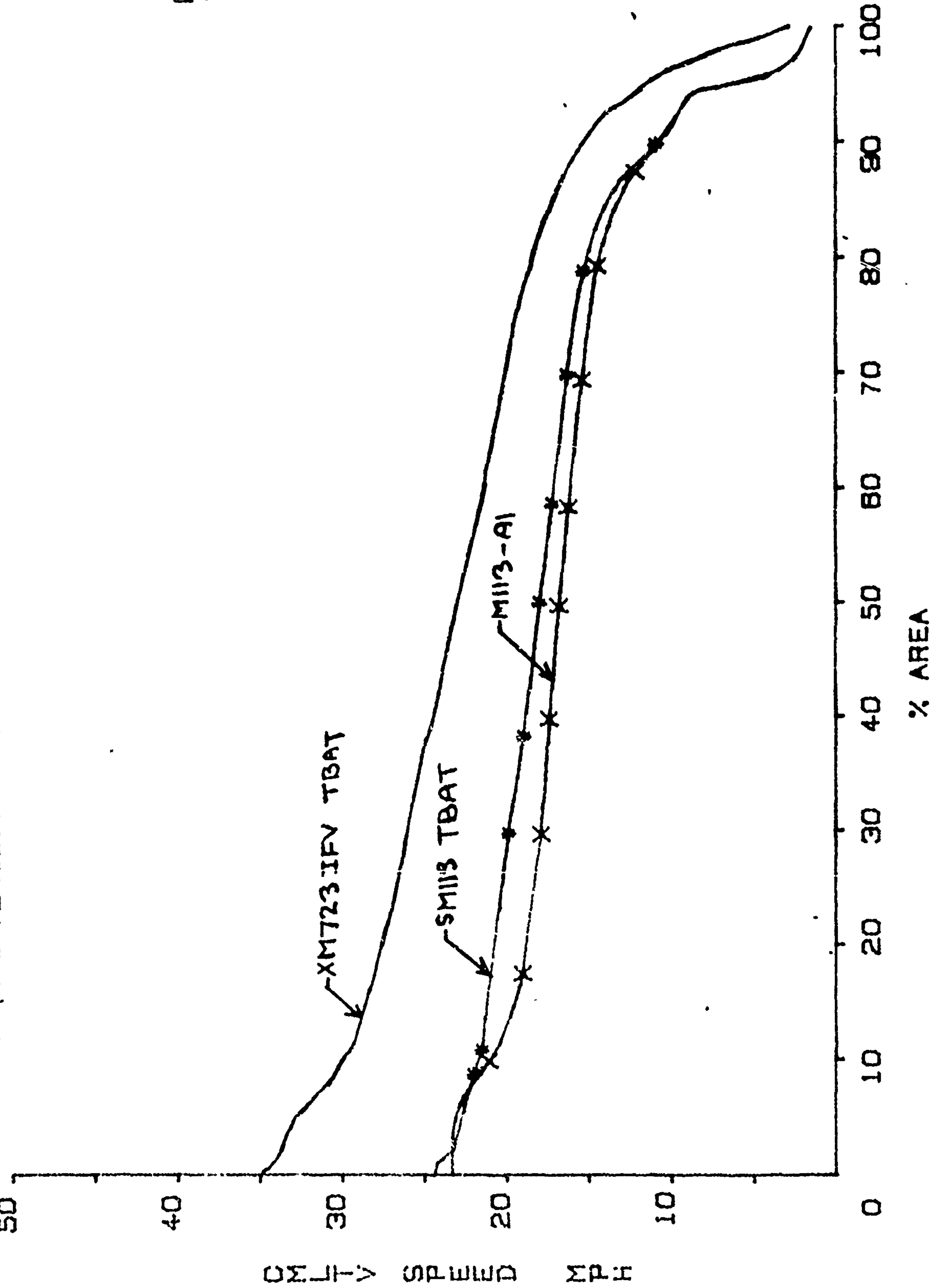
TABLE A-4 PREDICTED ACTUAL SPEEDS

Vehicle	WEST GERMANY AREAS			JORDEN AREA		
	V_{50}, MPH	V_{90}, MPH	PERCENT NO GO*	V_{50}, MPH	V_{90}, MPH	PERCENT NO GO*
M113A1	14.4	2.0	5.2	10.8	.1	9.9
IFV, TBAT	17.3	4.3	1.9	14.2	1.7	0.1
SM113, TBAT	14.7	1.8	5.3	11.9	1.0	1.6
SM113, BAT	15.0	1.9	5.7	11.9	1.0	1.6
SM113, TAT	15.0	2.0	5.7	11.8	1.0	1.6
SM113, ITV	15.3	2.0	5.7	11.9	1.0	1.6
M113A1E1, ITV	16.4	2.5	5.6	14.2	1.6	9.8
IFV, ITF	17.8	4.3	1.7	14.2	1.7	0.1

SOURCE: Army Mobility Model

*Percent of Total Area

FIG A-2. VEHICLE PERFORMANCE IN GERMANY TERRAIN



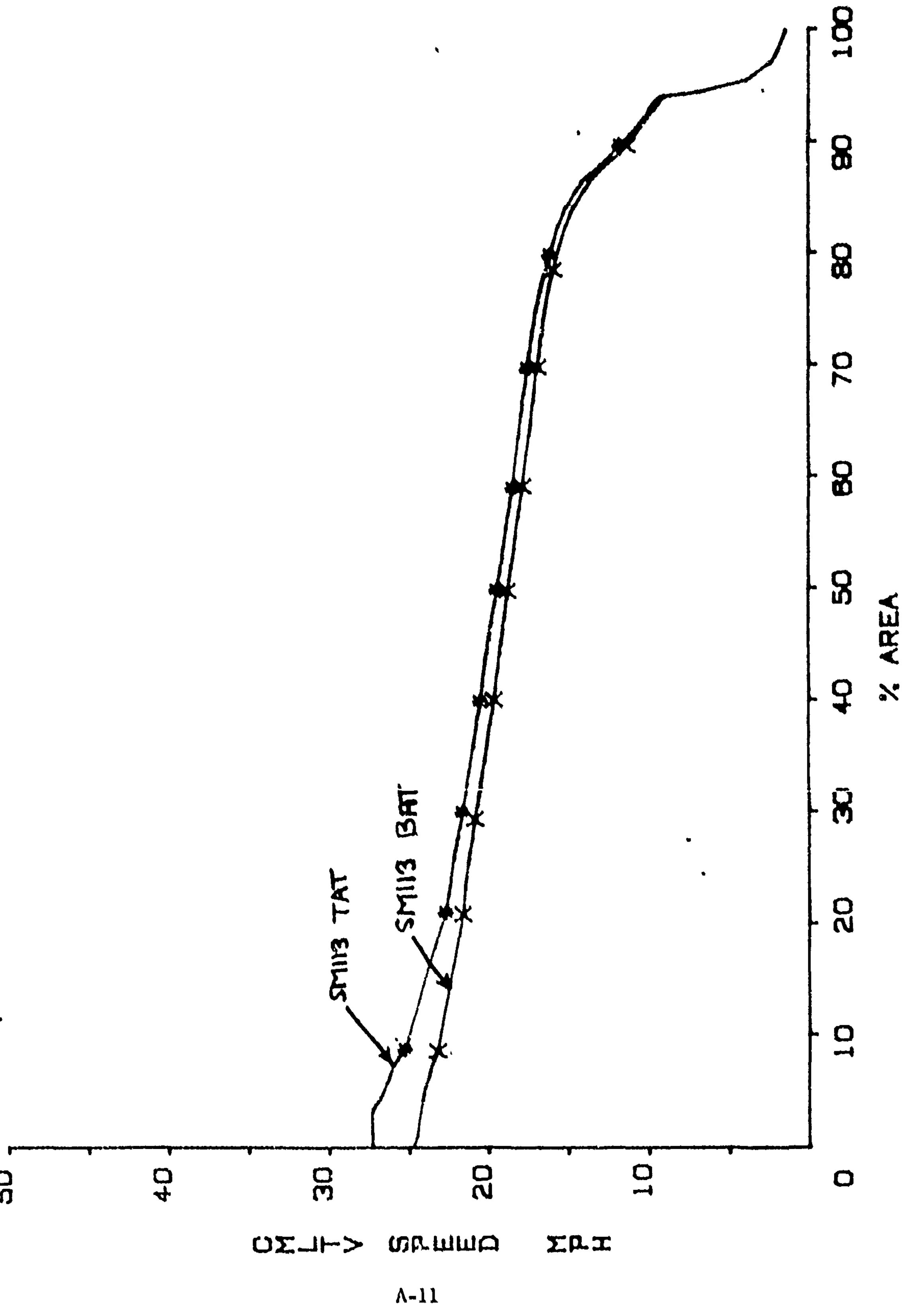


FIG A-3 VEHICLE PERFORMANCE IN GERMAN TERRAIN

FIG A-4 VEHICLE PERFORMANCE IN GERMANY TERRAIN

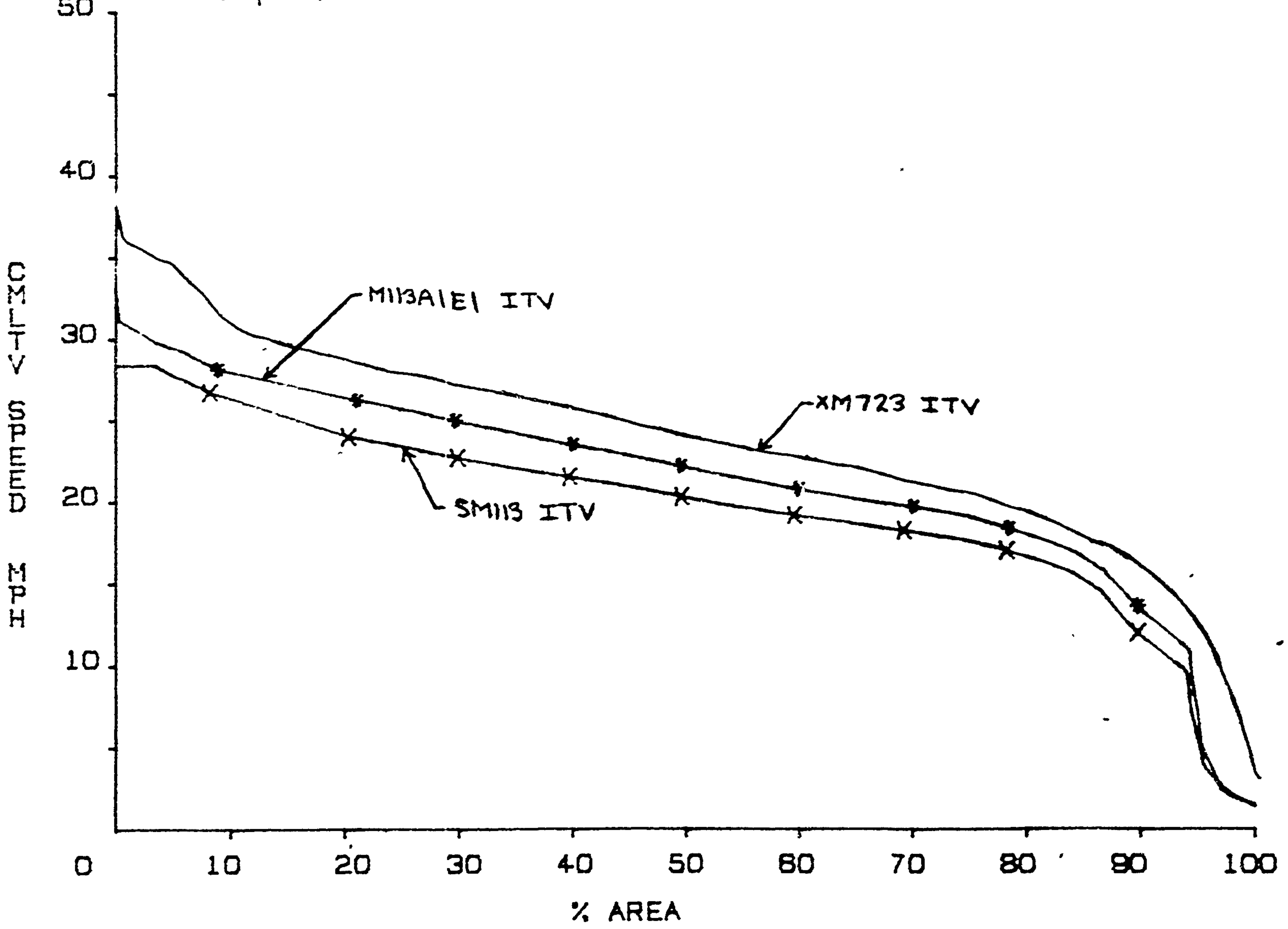


FIG A-5 VEHICLE PERFORMANCE IN JORDAN TERRAIN

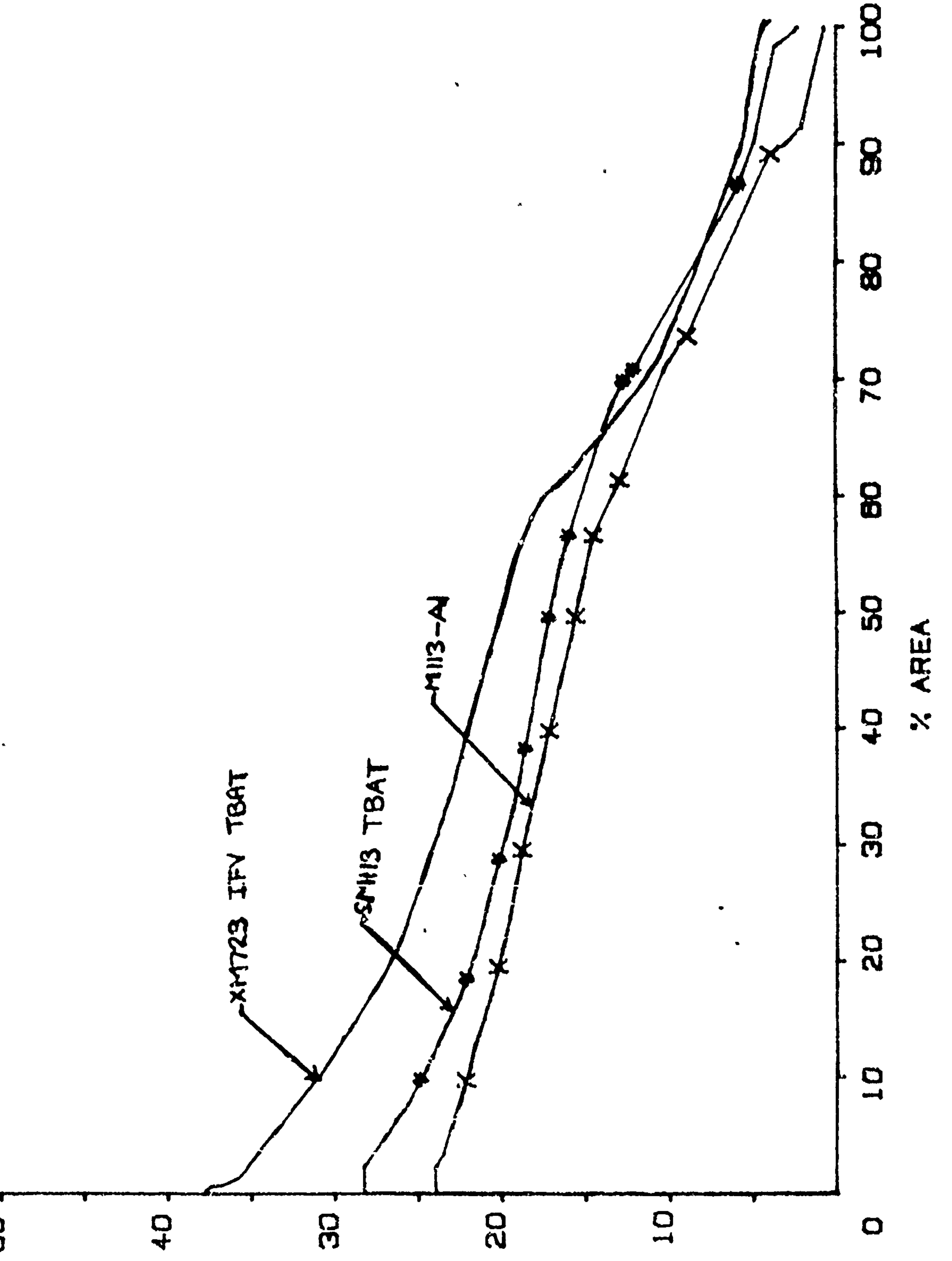


FIG A-6 VEHICLE PERFORMANCE IN JORDAN TERRAIN

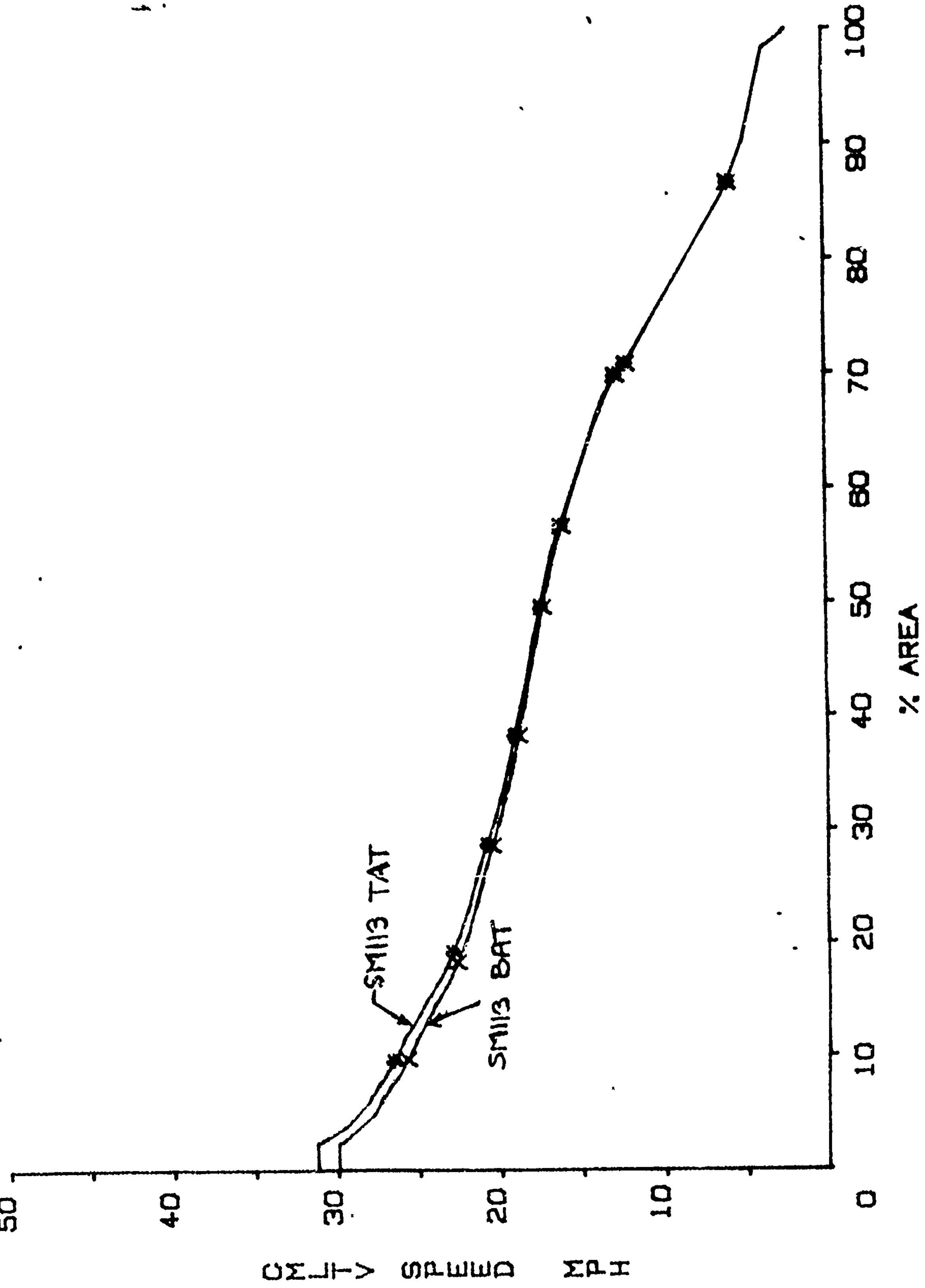
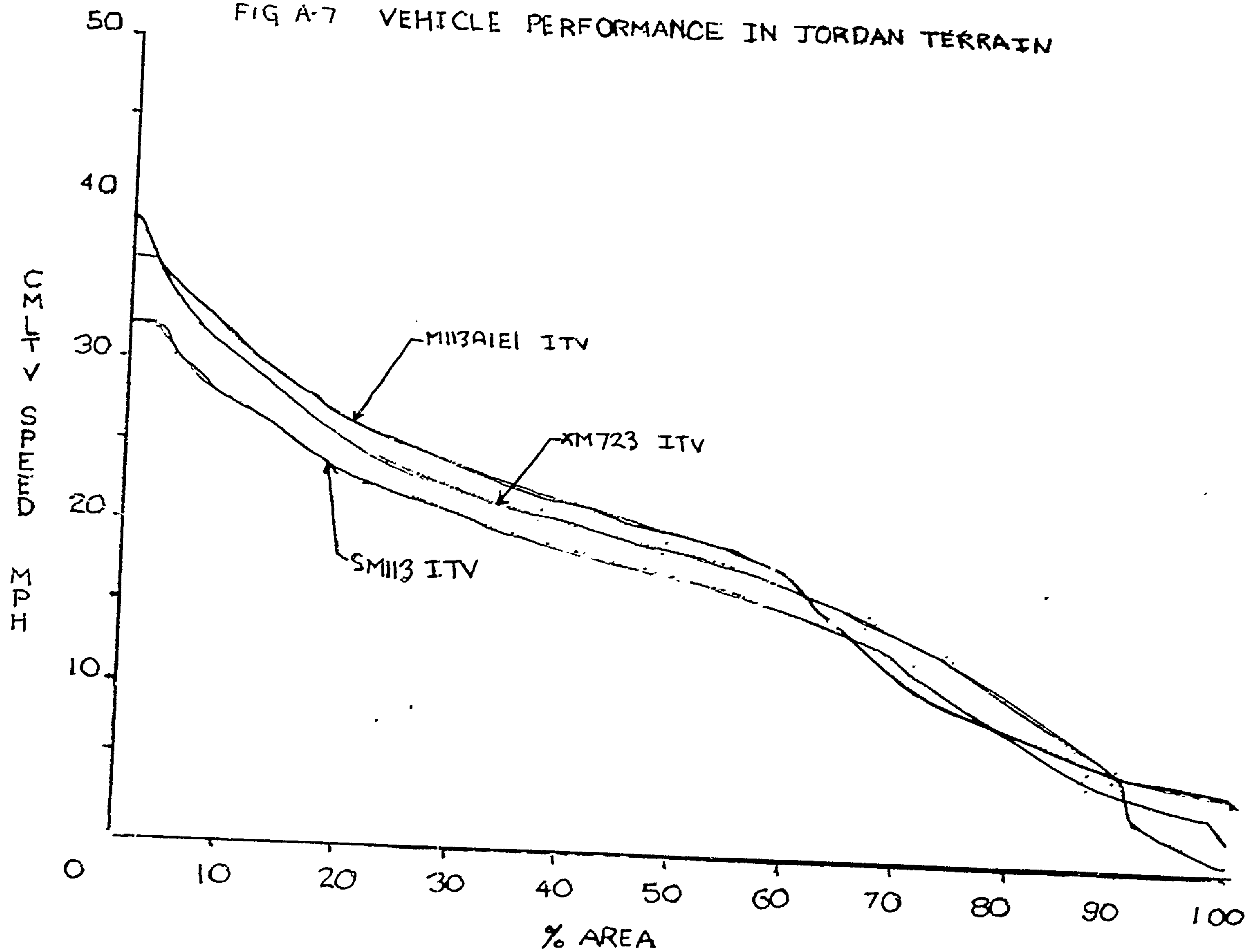


FIG A-7 VEHICLE PERFORMANCE IN JORDAN TERRAIN



M60A1 MBT. The XM-1 greatly out performs all configurations of both the stretched, product improved and standard M113A1 vehicles. Based on these speeds it seems that differenct tactics and command/control procedures might be necessary if the full speed potential of the faster XM-1 is to be realized in the mechanized infantry/armor team.

The second cross-country speed measure obtained with the Army Mobility Model is vehicle actual cross country speed. These results are shown in a summary form in table A-4. These speeds are the actual speeds predicted for the fifty and ninety percentile terrains for each area. Here again speed profiles are generated with speeds ordered in terms of trafficability. These profiles are shown in figures A-8 through A-13. Actual speeds indicate how fast a vehicle can go in a specific percentile terrain, rather than the average speed over all the terrain up to that point, as indicated by the previously discussed cumulative average speed. Again the stretched configurations show slightly faster speeds than those predicted for the standard M113A1. As before the M113A1E1, ITV, the product improved M113A1, shows the best speed performance of the M113A1 configurations. Both IFV configurations also out perform the stretched configurations. The IFV, ITV out performs the M113A1E1, ITV, in the West Germany terrain, but is equalled performance by that vehicle in the Jordan terrain.

Similar actual speed performance of the XM-1 and M60A1 tanks is as follows:

	WEST GERMANY			JORDAN		
VEHICLE	V_{50},mph	V_{90},mph	PERCENT NO GO	V_{50},mph	V_{90},mph	PERCENT NO GO
XM-1	19.6	5.4	2.4	13.5	7.6	-
M60A1	11.8	1.5	7.7	10.0	3.0	9.6

Comparison of these predictions indicates that on an actual speed basis all the SM113 configurations have lower speeds than the XM-1 and higher speeds than the M60A1 in all but the ninety percentile of the Jordan area.

The M113A1E1, ITV is also slower than the XM-1 in West Germany terrain but shows a slight speed advantage in the 50 percent easiest terrain of the Jordan area.

B. Factors Controlling Vehicle Speed and Causing NO-GO Conditions

The diagnostics routine of the Army Mobility Model provides an analysis of the terrain/vehicle factors controlling vehicle speeds and causing no go situations. These results for the M113A1 and IFV vehicle configurations investigated are shown in tables A-5 and A-6. Table A-3 shows the total percent of each area that is no go for each vehicle.

FIG A-8 VEHICLE PERFORMANCE IN GERMANY TERRAIN

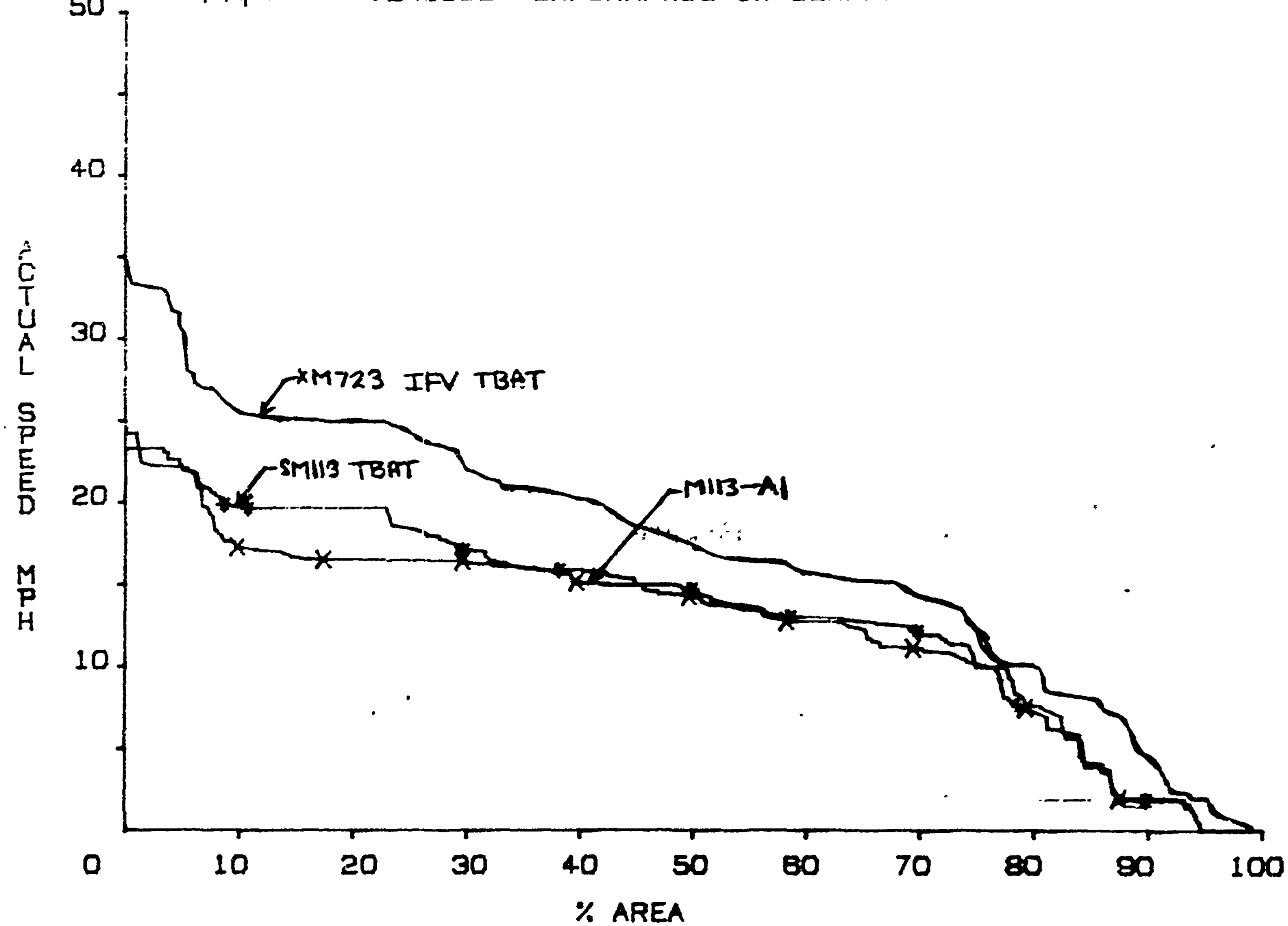


FIG A-9 VEHICLE PERFORMANCE IN GERMAN TERRAIN

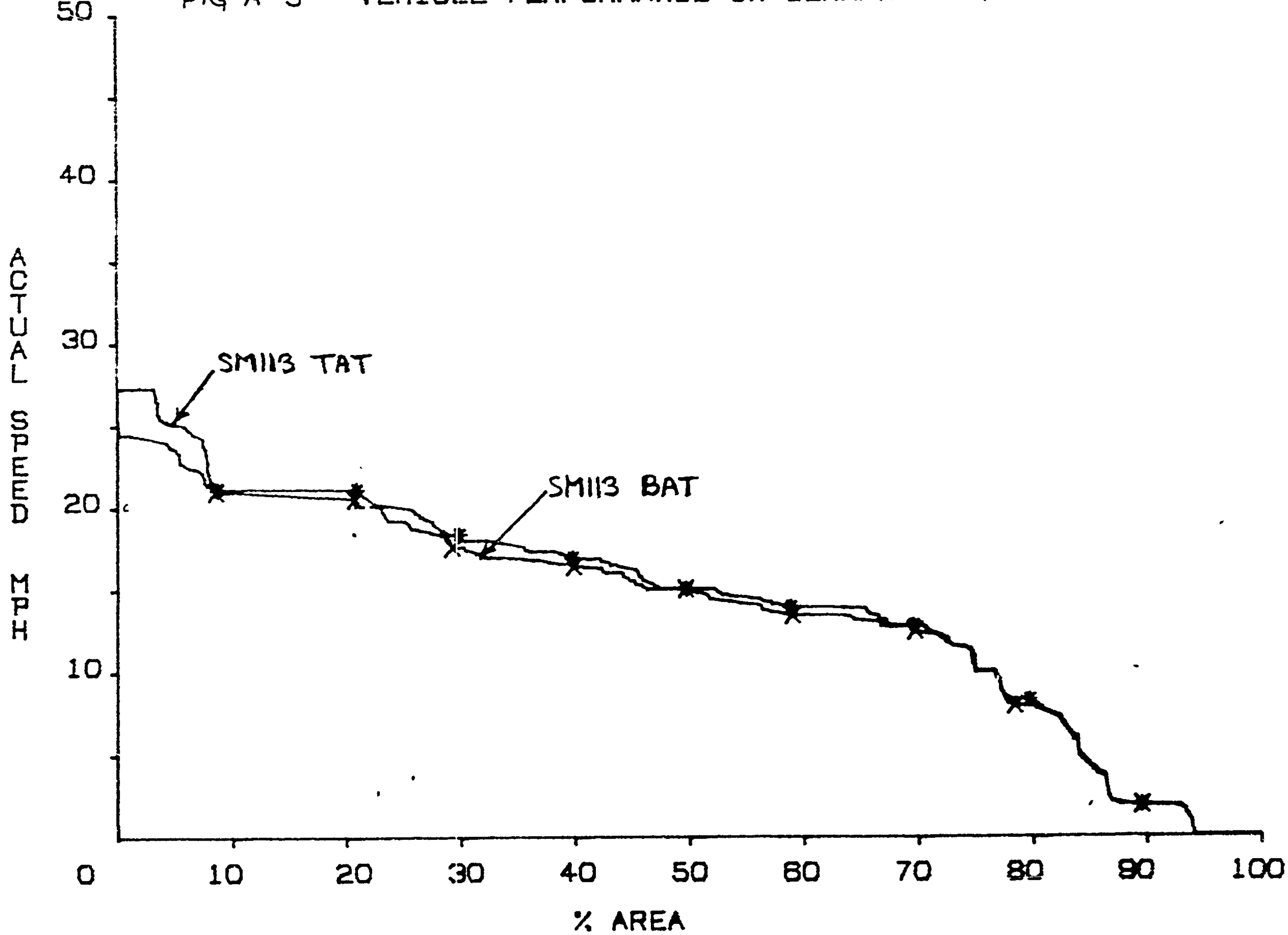


FIG. A-10 VEHICLE PERFORMANCE IN GERMANY TERRAIN

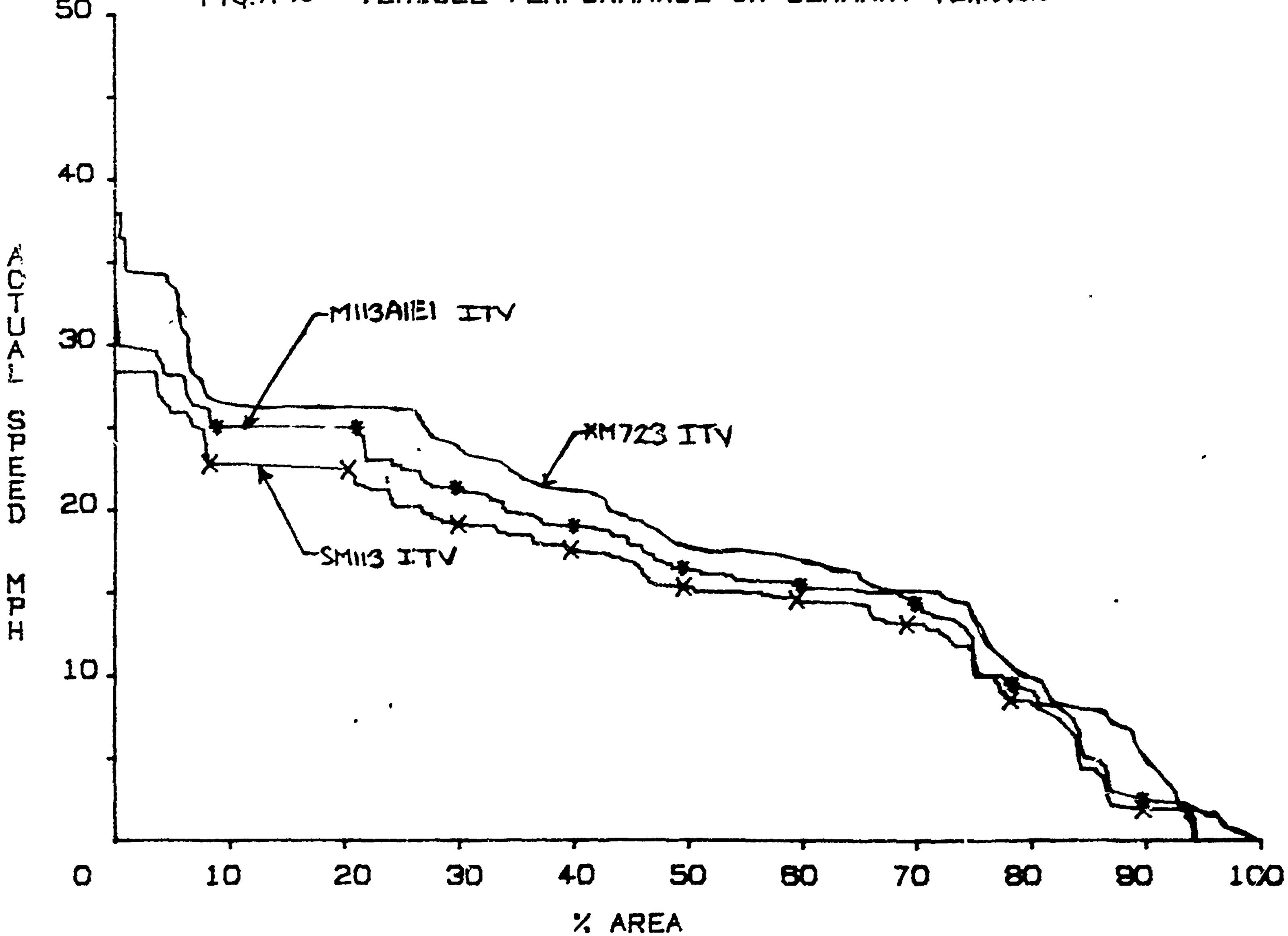


FIG A-11 VEHICLE PERFORMANCE IN JORDAN TERRAIN

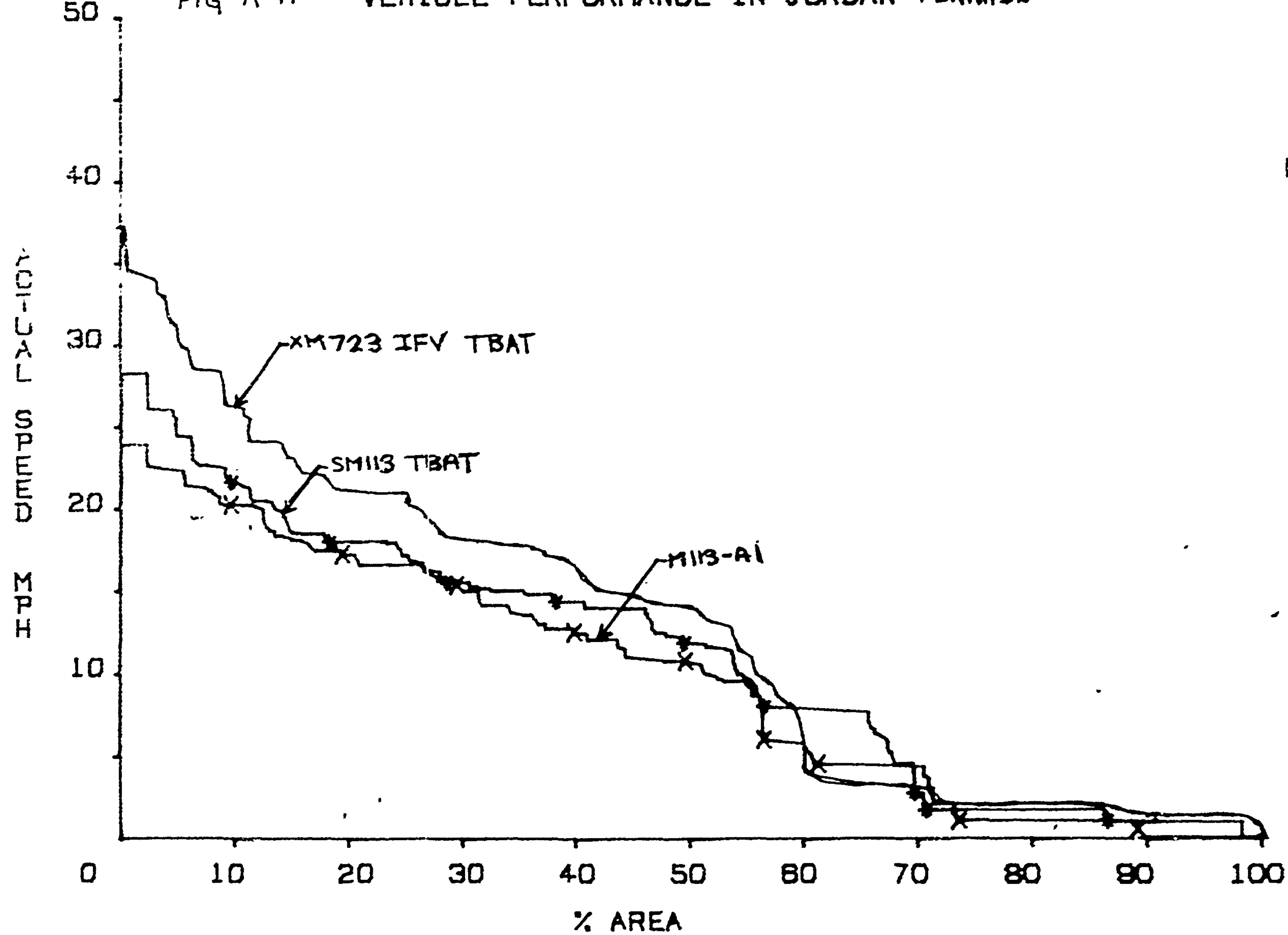


FIG A-12 VEHICLE PERFORMANCE IN JORDAN TERRAIN

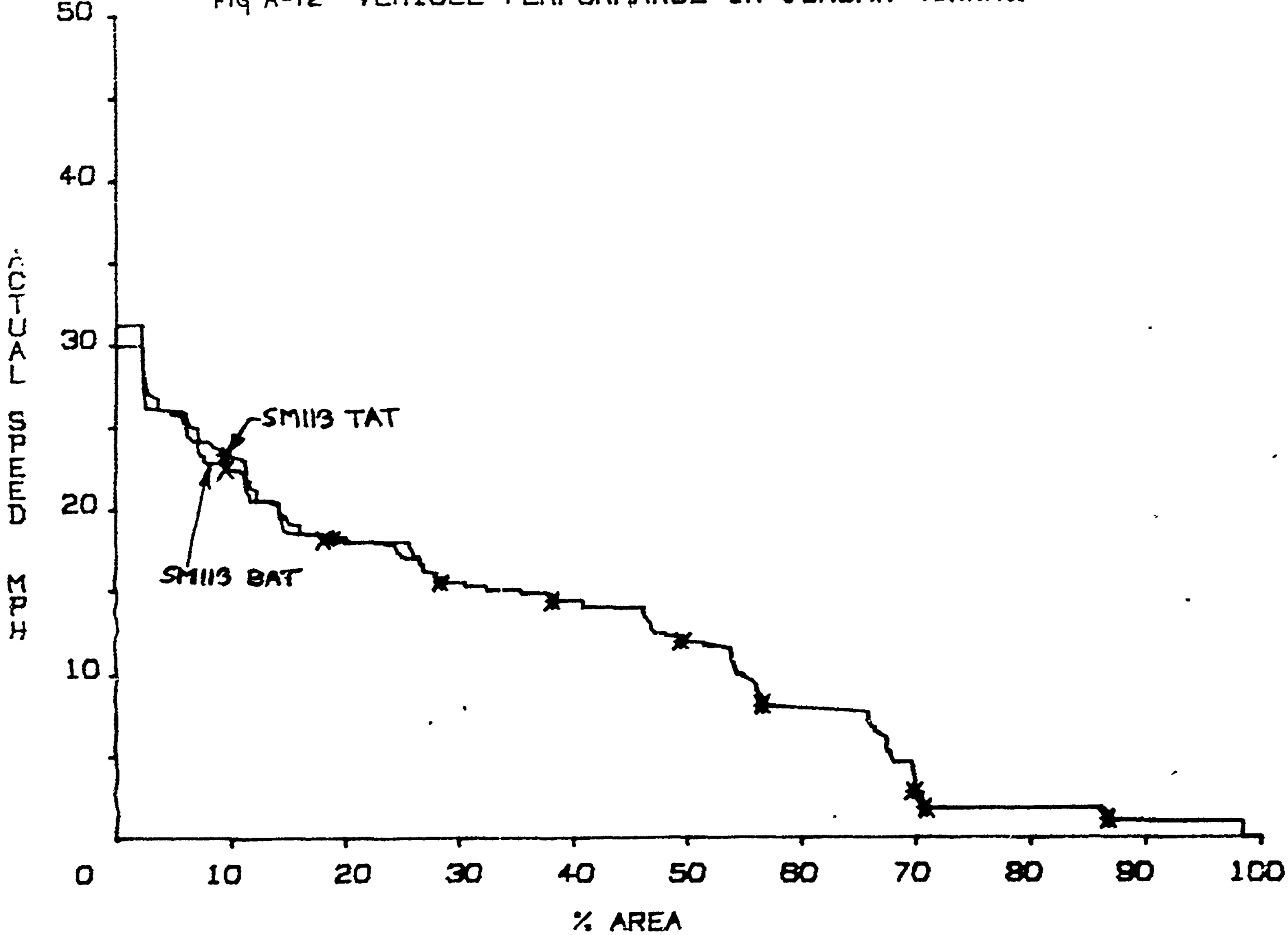
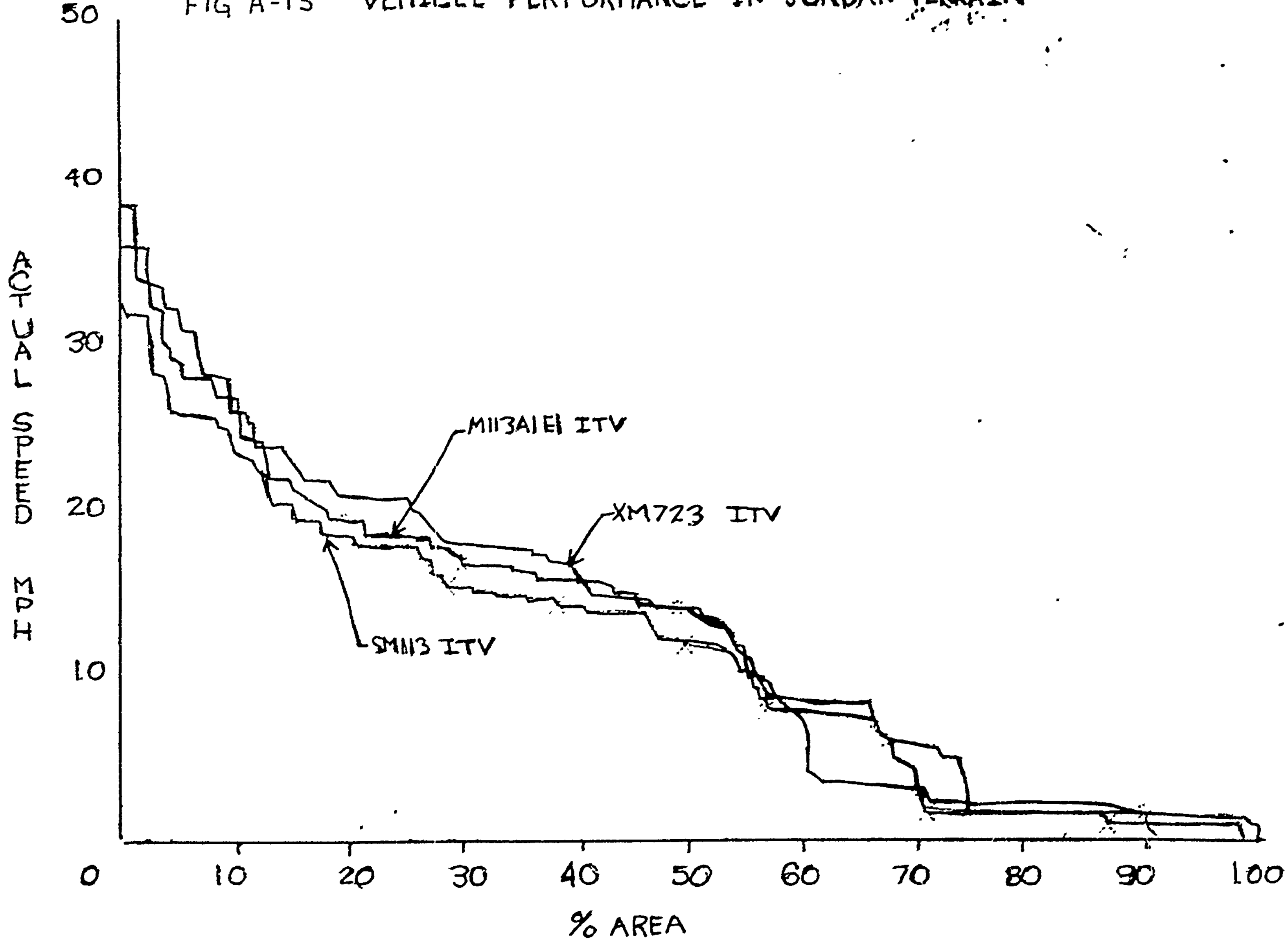


FIG A-13 VEHICLE PERFORMANCE IN JORDAN TERRAIN



For the West Germany area the major factor causing vehicle no go's is obstacles.

Both IFV configurations also have no go's due to obstacles, but on a total area basis they are immobilized less frequently. This probably reflects the IFV's better approach and departure geometry and higher momentum when impacting the obstacles.

The stretched configurations' no go's in Jordan are caused entirely by obstacles. The large difference is no go performance between the M113A1, M113A1E1 and the stretched configurations is caused by one terrain unit that accounts for 8.2 percent of the total area. In this unit the stretched vehicles use their greater momentum, due to higher gross vehicle weights, to over come the obstacles present. Again both IFV configurations show better no go performance.

Table A-6 shows on a percent of area basis the factors controlling vehicle speeds in each area. The major factor limiting vehicle performance in West Germany is soil and slope resistance. This reflects the occurrence of steep slopes and weaker wet season soil strengths found in West Germany. In the other area, Jordan, the factor mainly controlling speed is the obstacle spacing and heights that require frequent vehicle accelerations and braking actions to cross them. The high percent of the Jordan area where vehicle ride is the limiting factor also reflects the greater occurrence of higher values of surface roughness as compared to the West Germany area.*

*See Table A-1

TABLE A-5 AREAL OCCURRENCE OF FACTORS CAUSING VEHICLE NO GO's

VEHICLE	AREA	SURFACE STRENGTH LESS THAN VCI_1	AVAILABLE TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE PERFORMANCE	AVAILABLE TRACTION LESS THAN TOTAL RESISTANCE FORCES
M113A1	WEST GERMANY	-- %	.1 %	5.1 %	-- %
IFV, TBAT	WEST GERMANY	--	--	1.9	--
SM113, TBAT	WEST GERMANY	--	--	5.0	0.3
SM113, BAT	WEST GERMANY	--	--	5.2	0.5
SM113, TAT	WEST GERMANY	--	--	5.2	0.5
SM113, IFV	WEST GERMANY	--	--	5.2	0.5
M113A1E, ITV	WEST GERMANY	--	.1	5.0	0.4
IFV, ITV	WEST GERMANY	--	--	1.7	--
M113A1	JORDAN	--	--	9.9	--
IFV, TBAT	JORDAN	--	--	0.1	--
SM113, TBAT	JORDAN	--	--	1.6	--
SM113, BAT	JORDAN	--	--	1.6	--
SM113, TAT	JORDAN	--	--	1.6	--
SM113, IFV	JORDAN	--	--	1.6	--
M113A1E1, ITV	JORDAN	--	--	9.9	--
IFV, ITV	JORDAN	--	--	0.1	--

TABLE A-6. AREAL OCCURRENCE OF FACTORS LIMITING VEHICLE SPEEDS

Vehicle	Area	Factors Limiting Vehicle Speed, Percent of Area: Ride	Soil & Slope Resistance	Visibility	Maneuvering	All Resisting Forces	Accel & Decel Between Obstacles	Urban Areas
M113A1	West Germany	1.8%	49.1%	-	18.4%	18.7%	1.7%	All Vehicles Are Limited In 4.5% of Area
IFV, TBAT		1.8	44.2	6.2	15.7	17.7	7.5	
SM113, TBAT		1.4	53.0	-	17.8	14.1	3.5	
SM113, BAT		2.0	51.5	-	17.6	14.7	3.5	
SM113, TAT		2.0	48.5	-	17.6	17.6	3.6	
SM113, ITV		2.0	48.4	-	17.6	17.8	3.5	
M113A1E1, ITV		1.7	49.6	1.6	17.6	15.7	3.4	
IFV, ITV		3.2	42.1	8.1	15.7	16.5	7.7	
M113A1	Jordan	18.9	8.7	-	12.1	3.3	44.6	All Vehicles Are Limited In 2.2% of Area
IFV, TBAT		29.9	0.0	0.8	23.3	3.7	39.6	
SM113, TBAT		23.7	4.0	-	7.8	7.0	53.2	
SM113, BAT		24.7	4.0	-	7.8	6.9	52.4	
SM113, TAT		24.8	2.3	-	7.0	7.6	54.1	
SM113, ITV		27.7	2.3	-	6.9	5.5	53.3	
M113A1E1, ITV		33.0	2.3	0.1	12.0	4.5	35.7	
IFV, ITV		30.6	0.1	1.8	23.6	1.4	39.7	

C. Speeds on Slopes

Table A-7 shows the predicted maximum speeds for three conditions of soil strength and slope. These speeds depict a vehicle's capability based only on consideration of its power train and tractive elements. The soil and slope conditions examined represent the range of conditions occurring in the West Germany area.

All the SM113 configurations have higher predicted speeds than the current standard M113A1. These results reflect the improved power train of the stretched configurations. In general all SM113 configurations out perform the M60A1 tank, but fall far below the performance predicted for the XM-1 tank.

The IFV configurations both show predicted performance greater than the SM113 configurations.

Table A-7A shows predicted maximum vehicle speeds on paved slopes.

D. Acceleration Performance

Table A-8 shows the predicted accleration performance for the various vehicles operating in both level and sloping fine grain soils. In the firm soil condition, RCI 130, all the SM113 configurations have generally better predicted performance than the existing standard M113A1. The M113A1E1 vehicle is predicted to have the best performance both in time and top speeds achieved. In crossing gap distances of 100 m and 200 m, except for the SM113 TBAT, the stretched vehicles require from one to five seconds less time than the standard M113A1. Again the M113A1E1 provides the best performance of the M113A1 type vehicles with a two to seven second advantage over the standard M113A1. The performance advantage of the M113A1E1 vehicle reflects its low gross weight, compared the stretched configurations, and its final drive gearing to provide a top speed of 40 mph.

The IFV configurations examined show better performance than the equivalent configurations, i.e. TBAT and IFV, of the SM113 and the M113A1E1 vehicles for 130 RCI soil strength.

For the 36 RCI soil strength condition all vehicles show lower maximum speeds and increased times. This reflects the increased vehicle motion resistance caused by the weaker soil strength conditions. As before the M113A1E1 is predicted to have the best performance of the M113A1 configurations and the IFV configurations again show better performance than the SM113 and M113A1E1 vehicles.

For comparison similar acceleration performance for the XM-1 and M60A1 is shown in table A-9. The SM113 vehicles' performance is better than that of the M60A1, but less than that predicted for the XM-1 in all conditions examined.

TABLE A-7 PREDICTED VEHICLE SPEEDS ON FINE GRAIN SOIL SLOPES

	SOIL STRENGTH								
	60 RCI			120 RCI			290 RCI		
	SLOPE			SLOPE			SLOPE		
VEHICLE	0%	20%	40%	0%	20%	40%	0%	20%	40%
M113A1	21.2 MPH	6.2 MPH	2.3 MPH	35.8 MPH	8.5 MPH	2.5 MPH	41.8 MPH	9.1 MPH	2.6 MPH
IFV, TBAT	36.9	9.1	5.3	40.7	10.6	5.6	40.8	11.4	5.7
SM113, TBAT	23.5	7.4	3.0	29.8	8.2	3.5	29.9	8.5	3.7
SM113, BAT	24.6	7.5	3.0	32.8	8.7	3.5	32.9	9.1	3.7
SM113, TAT	27.1	7.4	2.8	37.8	8.8	3.3	37.8	9.7	3.5
SM113, ITV	28.8	7.7	3.1	39.8	9.6	3.6	39.8	10.3	3.8
M113A1E1, ITV	30.9	10.1	4.2	39.8	11.0	4.5	39.8	11.4	5.1
IFV, ITV	40.1	11.1	5.9	40.7	12.6	6.0	40.8	13.5	6.1
XM1	33.0	10.5	6.0	43.7	11.6	6.3	43.8	13.9	6.4
M60A1	16.3	5.5	2.0	23.4	6.3	2.4	30.0	6.7	2.6

TABLE A-7A PREDICTED MAXIMUM SPEED PERFORMANCE ON PAVED SLOPES

VEHICLE	SPEED ON "X" PERCENT SLOPE, MPH				
	Level	5%	10%	15%	20%
SM113, TBAT	30.0	24.7	14.7	11.7	9.0
SM113, BAT	33.0	25.8	15.7	10.9	9.6
SM113, TAT	38.0	28.3	17.6	11.8	10.5
SM113, ITV	40.0	29.7	18.7	12.6	11.2
M113A1E1, ITV	40.0	33.7	19.7	15.9	12.0

TABLE A-8 PREDICTED VEHICLE ACCELERATION PERFORMANCE IN FINE GRAIN SOIL

VEHICLE	TERRAIN CONDITIONS		TIME REQUIRED TO REACH "X" MPH, SECONDS			TIME REQUIRED TO TRAVEL "X" METERS, SECONDS	
	SOIL STRENGTH, RCI	SLOPE, %	10 MPH	20 MPH	30 MPH	100 M	200 M
M113A1	130	0	2.9	10.9	59.6	14.6	22.4
		10	5.1	11.3 mph max	--	22.2	42.0
		15	9.0	10.6 mph max	--	24.0	45.1
IFV, TBAT		0	1.8	5.7	13.9	11.8	18.9
		10	2.6	19.5 mph max	--	15.5	27.1
		15	3.6	14.4 mph max	--	18.6	34.1
SM113, TBAT		0	3.0	11.9	38.6	14.9	24.0
		10	5.8	13.4 mph max	--	20.6	37.4
		15	9.3 mph max	--	--	26.0	50.0
SM113, BAT		0	2.8	11.1	35.8	14.5	23.5
		10	4.7	14.1 mph max	--	20.2	36.1
		15	11.0	10.0 mph max	--	24.5	46.8
SM113, TA.		0	2.6	9.9	28.8	14.0	22.7
		10	4.3	14.6 mph max	--	19.6	35.3
		15	7.1	11.0 mph max	--	22.8	43.1

TABLE A-8 PREDICTED VEHICLE ACCELERATION PERFORMANCE IN FINE GRAIN SOIL (Cont'd)

VEHICLE	TERRAIN CONDITIONS SOIL STRENGTH, RCI	TERRAIN CONDITIONS SLOPE %	TIME REQUIRED TO REACH "X" MPH, SECONDS 10 MPH	20 MPH	30 MPH	TIME REQUIRED TO TRAVEL "X" METERS, SECONDS 100 M	200 M
SM113 ITV	130	0	2.4	8.7	24.6	13.6	22.0
		10	3.8	15.7 mph max	--	18.6	33.3
		15	5.9	11.0 mph max	--	21.7	40.9
M113A1E1 ITV	130	0	2.1	7.2	18.8	12.8	20.6
		10	3.1	18.0 mph max		16.7	29.3
		15	4.1	12.4 mph max		20.2	38.2
IFV ITV	130	0	1.6	4.9	11.5	11.2	18.0
		10	2.3	12.8	22.6 mph max	14.4	24.8
		15	2.9	16.5 mph max	--	16.8	30.4
M113A1	36	0	4.1	--	--	19.2	33.5
		10	9.9 mph max	--	--	25.7	48.3
		15	7.6 mph max	--	--	34.0	63.6
IFV TBAT	36	0	2.3	9.6	26.3 mph max	13.8	23.1
		10	4.1	13.5 mph max	--	19.4	36.0
		15	16.4	10.0 mph max	--	24.5	47.0
SM113 BAT	36	0	4.0	15.4 mph max	--	18.3	32.8
		10	9.4 mph max	--	--	26.1	50.0
		15	7.7 mph max	--	--	31.5	60.7
SM113 TAT	36	0	3.6	17.4 mph max	--	17.4	30.2
		10	12.3	10.3 mph max	--	24.6	46.3
		15	7.6 mph max	--	--	31.2	60.7
SM113 ITV	36	0	3.2	18.7 mph max	--	16.5	28.5
		10	7.7	11.05 mph max	--	22.9	43.1
		15	8.2 mph max	--	--	29.3	56.7

TABLE A-8 PREDICTED VEHICLE ACCELERATION PERFORMANCE IN FINE GRAIN SOIL (Cont'd)

VEHICLE	TERRAIN CONDITIONS SOIL STRENGTH, RCI	TERRAIN CONDITIONS SLOPE %	TIME REQUIRED TO REACH "X" MPH, SECONDS 10 MPH	20 MPH	30 MPH	TIME REQUIRED TO TRAVEL "X" METERS, SECONDS 100 M	200 M
M113A1E1 ITV	36	0	2.7	19.4 mph max	--	15.4	22.6
		10	5.0	11.8 mph max	--	21.3	40.3
		15	12.2	10.3 mph max	--	24.4	46.2
IFV ITV		0	1.9	7.3	42.5	12.8	21.3
		10	3.0	15.6 mph max	--	17.3	31.6
		15	4.6	12.1 mph max	--	20.9	39.5

TABLE A-9 PREDICTED XM-1 AND M60A1 ACCELERATION PERFORMANCE IN FINE GRAIN SOIL

VEHICLE	TERRAIN CONDITIONS		TIME REQUIRED TO REACH "X" MPH, SECONDS			TIME REQUIRED TO TRAVEL "X" METERS, SECONDS	
	SOIL STRENGTH RCI	SLOPE %	10 MPH	20 MPH	30 MPH	100M	200M
XM1	130	0	2.3	6.7	15.8	12.5	19.9
		10	3.1	17.7	21.9 mph Max.	15.8	26.6
		15	3.9	14.9 mph Max.	—	18.3	33.3
	36	0	3.5	20.0	20.2 mph Max.	16.7	28.2
		10	6.3	11.1 mph Max.	—	22.9	43.0
		15	9.4 mph Max.	—	—	26.5	50.2
M60A1	130	0	4.0	21.0	23.7 mph Max.	16.9	27.8
		10	14.7	10.2 mph Max.	—	24.8	46.8
		15	7.7 mph Max.	—	—	30.9	59.8
	36	0	11.0	10.6 mph Max.	—	24.2	45.4
		10	6.5 mph Max.	—	—	36.0	70.3
		15	5.2 mph Max.	—	—	44.8	88.1

TABLE A-10 PREDICTED LEVEL PAVED ACCELERATION PERFORMANCE

VEHICLE	TIME REQUIRED TO REACH "X" MPH, SECONDS			MEETS IFV REQUIREMENT FOR 30 MPH
	10 MPH	20 MPH	30 MPH	
SM113, TBAT	2.6	9.0	21.1	YES
SM113, BAT	2.5	8.5	20.0	
SM113, TAT	2.3	7.8	17.9	
SM113, ITV	2.2	7.0	16.3	
M113A1E1, ITV	1.9	6.0	13.6	

The AMSAA acceleration model was operated to determine the capabilities of the M113A1 vehicle configurations to meet the IFV specification requirement for acceleration. The IFV requirement for acceleration on a level paved surface is to attain 30 mph from a standing start in 18 to 22 seconds. The model predicted results for this condition are shown in table A-10.

E. Road and Trail Performance

Table A-11 shows the predicted average speeds obtained from the on-road mobility model. These results reflect a single vehicle and do not consider the effect of convoy speed limits and command/control restraints. These predictions consider a vehicle's available power, traction, ride and stability (sliding and tipping) when operating on the following classes of roads:

Class 1 - Primary: Surfaced all weather roads, two lanes or more

Class 2 - Secondary: The balance of the all weather roads, generally unpaved but improved, plus paved roads less than two lanes wide.

Class 3 - Trails: Unimproved and fair weather roads and trails of at least one vehicle width.

The SM113 configurations generally have performance similar to that of a standard M113A1, except for the TBAT and BAT configurations on paved roads where their top speed gearing restricts their speeds. The lighter configurations, the TAT, ITV, and the M113A1E1 ITV equal or exceed the M113A1 because of their higher top speed gearing limits and their lower gross weights.

Compared to the IFV configurations the M113A1 configurations all have lower levels of predicted performance. The M113A1 configurations performance is better than that of the M60A1, but less than that predicted for the XM-1.

TABLE A-11 PREDICTED ROAD PERFORMANCE

VEHICLE	AVERAGE SPEED, MPH					
	WEST GERMANY			YUMA		
	PAVED ROADS	SECONDARY ROADS	TRAILS	PAVED ROADS	SECONDARY ROADS	TRAILS
M113A1	34.3	25.0	14.3	41.4	27.2	14.2
IFV TBAT	39.4	33.2	19.1	40.5	32.2	19.4
SM113 TBAT	29.1	25.1	15.3	30.0	27.3	15.9
SM113 BAT	31.4	26.2	15.6	33.0	28.2	16.0
SM113 TAT	34.5	28.1	16.1	37.6	29.5	16.0
SM113 ITV	36.4	29.1	16.5	39.4	30.0	16.4
M113A1E1 ITV	37.8	31.2	17.5	39.6	31.6	17.9
IFV ITV	39.8	34.0	19.7	40.5	32.2	19.5
XM1	41.1	37.0	22.5	43.4	43.1	25.2
M60A1	23.9	18.9	14.1	27.2	23.3	13.9

F. Fine Grain Soil Trafficability

The effect of track width on vehicle trafficability in fine grain soils was investigated by considering the use of a 17 inch wide track in place of the 15 inch currently proposed for the SM113 configurations. As shown in table A-12 the use of a 17 inch wide reduces the vehicle nominal ground pressure approximately 1 psi. In terms of the WES vehicle cone index, the soil strength in terms of remolded cone index (RCI) required for either one or fifty passes of the vehicle in level fine grain soil, the use of the wider track shows a 2 to 4 RCI reduction in one pass requirements and a 6 to 7 RCI reduction for fifty passes. These slight reductions in vehicle cone index requirements will have a negligible effect on improving fine grain soil trafficability.

For comparison the fine grain soil trafficability requirements and ground pressure for the IFV and MBT's are as follows:

	VCI_1	VCI_{50}	NOMINAL GRD PRESSURE, PSI
IFV, TBAT	13	32	7.5
M60A1	22	51	11.7
XM-1	25	58	12.7

From all of these data, it is apparent that even at 35,000 GVW, the 15 inch track provides adequate soft soil mobility, and that there is no performance risk that might suggest consideration of a 17 inch track.

TABLE A-12 EFFECT OF TRACK WIDTH ON ONE PASS/FIFTY PASS TRAFFICABILITY OF M113A1 CONFIGURATIONS IN FINE GRAIN SOILS

Vehicle Configuration	Gross Vehicle Weight, lbs.	Nominal Ground Pressure, psi		Fine Grain Soil Trafficability			
		15" Wide Track	17" Wide Track	One Pass VCI_1		Fifty Pass VCI_{50}	
				15"	17"	15"	17"
SM113 TBAT	35,000	8.9	7.8	19	15	44	37
SM113 BAT	33,500	8.5	7.5	18	15	42	36
SM113 TAT	31,500	8.0	7.1	17	14	41	35
SM113 ITV	29,500	7.5	6.6	16	14	39	33
M113A1E1 ITV	26,000	8.2	7.2	18	15	41	35
STD. M113A1	24,600	7.8	—	17	14	39	34
IFV TBAT	47,000	7.5 (21")	—	13 21"		32 21"	

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APPENDIX B

CONCEPT VEHICLE DESCRIPTIONS

CHARACTERISTICS
M113A1/M113A1E1

VEHICLE	WEAPON STATION	GVW LBS	GHP/TON	GROUND PRESSURE PSI	CRUISING RANGE MILE*	TOP SPEED MPH
M113A1	Cdr's	24,595	17.5	7.8	240	40
M113A1E1	Cdr's	24,600	22.4	7.8	310	39
M113A1	ITV/ACCV	26,000	16.5	8.2	230	38
Extended M113A1E1	ITV	29,500	18.6	7.5	250	40
Extended M113A1E1	TAT	31,500	17.5	8.0	270	38
Extended M113A1E1	BAT	33,500	16.4	8.5	250	33
Extended M113A1E1	TBAT	35,000	15.7	8.9	240	30

*APG Standard Fuel Course

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CHARACTERISTICS
M113A1

GENERAL

Weight, combat loaded	24,595 lbs
Ground pressure, combat loaded	7.8 psi
Personnel capacity	13
Fuel tank capacity	95 gallons

PERFORMANCE

Speed on land	40 mph
Cruising range	240 miles
Turning radius	Pivot to infinite
Slope	60%
Side slope	30%
Trench crossing	72 in
Vertical wall climbing	24 in
Cross horsepower-to-weight ratio	17.5 hp/ton

ENGINE

Make and model	Detroit Diesel 6V53
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	215

TRANSMISSION, AUTOMATIC

Make and model	Allison TX-100
Type	Hydrokinetic
Steering	Controlled Differential
Brake type	Drum & band

RUNNING GEAR

Suspension type	flat track
Springing media	Torsion bar
Number of wheels	5 pr per side
Wheel size	24 in diam, 2 1/8 in wide
Track type	Single pin
Shock absorbers	2 per side
Track pitch	6 in
Track width	15 in
Track weight	46 lbs/ft

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CHARACTERISTICS
M113A1 (Cont)

NIGHT VISION EQUIPMENT	
Sight, driver	M19
TURRET (One-Man)	
Armament	50 cal Machine Gun
Traverse	360 deg continuous
Elevation	+58 deg to -21 deg
Slew	Manually Operated
Ring gear, pitch diameter	30 in
SQUAD WEAPONS	
Rifles, M14 7.62 mm	2
AMMUNITION - Number of rounds	
7.62 mm (M60)	360 stowed
50 Cal	2000 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	100
Volts, dc	28
Batteries	2, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/GRR-5
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	5 lb CO_2
Portable	5 lb CO_2

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CHARACTERISTICS
M113A1E1

GENERAL	
Weight, combat loaded	24,600 lbs
Ground pressure, combat loaded	7.8 psi
Personnel capacity	13
Fuel tank capacity	95 gallons
PERFORMANCE	
Speed on land	39 mi/h
Cruising range	310 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	30%
Trench crossing	72 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	22.4 hp/ton
ENGINE	
Make and model	Detroit Diesel 6V53T
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	275
TRANSMISSION, AUTOMATIC	
Make and model	Allison X-200-3
Type	Hydrokinetic
Steering	Hydrostatic
Brake type	Multiple wet plate
RUNNING GEAR	
Suspension type	flat track
Springing media	Advanced torsion bar
Number of wheels	6 pr. per side
Wheel size	24 in diam, 2-1/8 in wide
Track type	Single pin
Shock absorbors	3 per side
Track pitch	6 in
Track width	15 in
Track weight	46 lbs/ft

CHARACTERISTICS
M113A1E1 (Cont)

NIGHT VISION EQUIPMENT	
Sight, driver	M19
TURRET (One-Man)	
Armament	50 Cal Machine Gun
Traverse	360 deg continuous
Elevation	+58 deg to -28 deg
Slew rate, maximum	] Manually Operated
Tracking rate, minimum	
Ring gear, pitch diameter	30 in
SQUAD WEAPONS	
Rifles, M14 7.62 mm	2
AMMUNITION - Number of rounds	
7.62 mm (M60)	360 stowed
50 Cal	2000 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	100
Volts, dc	28
Batteries	2, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/GRR-5
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	5 lb CO_2
Portable	5 lb CO_2

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CHARACTERISTICS
Improved TOW Vehicle (ITV), XM901

GENERAL	
Weight, combat loaded	26,000 lbs
Ground pressure, combat loaded	8.2 psi
Personnel capacity	5
Fuel tank capacity	95 gallons
PERFORMANCE	
Speed on land	38 mi/h
Cruising range	230 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	30%
Trench crossing	75 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	16.5 hp/ton
ENGINE	
Make and model	Detroit Diesel 6V53
Displacement	318 Cu in
Type	2 Cycle
Fuel	Diesel
Gross horsepower	215
TRANSMISSION, AUTOMATIC	
Make and model	Allison TX 100
Type	Hydrokinetic
Steering	Controlled Differential
Brake type	Drum and Band
RUNNINC GEAR	
Suspension type	Flat track
Springing media	Torsion bar
Number of wheels	5 pr. per side
Wheel size	24 in diam, 2-1/8 in wide
Track type	Single pin
Shock absorbors	2 per side
Track pitch	6 in
Track width	15 in
Track weight	46 lbs/ft

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CHARACTERISTICS
Improved TOW Vehicle (ITV), XM901

NIGHT VISION EQUIPMENT	
Sight, gunner	AN/TAS-4
Sight, commander	None
Sight, driver	M19
TURRET (One-Man)	
Armament	TOW Missile launcher, 7.62mm, M60 M.G.
Traverse	360 deg. continuous
Elevation	
TOW missile launcher	+30 deg. to -31 deg.
7.62 mm	pintile mount
Slew rate, maximum	45 deg/sec
Tracking rate, minimum	0.1 mil/sec
Stabilization system	Electrohydraulic
Ring gear, pitch diameter	34 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	5
AMMUNITION - Number of rounds	
7.62mm (M60)	4600 stowed
5.56mm (M16A1)	720 stowed
TOW missiles	2 in launcher
TOW missiles	10 stowed
LAW-M72A2	3 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	100
Volts, dc	28
Batteries	2, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/VRC-64
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	5 lb CO_2
Portable	5 lb CO_2

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CHARACTERISTICS
M113A1 w/ACCV

GENERAL

Weight, combat loaded	26,000 lbs
Ground pressure, combat loaded	8.2 psi
Personnel capacity	5
Fuel tank capacity	95 gallons

PERFORMANCE

Speed on land	38 mi/h
Cruising range	230 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	30%
Trench crossing	72 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	16.5 hp/ton

ENGINE

Make and model	Detroit Diesel 6V53
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	215

TRANSMISSION, AUTOMATIC

Make and model	Allison TX-100
Type	Hydrokinetic
Steering	Controlled Differenctial
Brake type	Drum and Band

RUNNING GEAR

Suspension type	Flat track
Springing media	Torsion bar
Number of wheels	5 pr. per side
Wheel size	24 in diam, 2-1/8 in wide
Track type	Single pin
Shock absorbors	2 per side
Track pitch	6 in
Track width	15 in
Track weight	46 lbs/ft

CHARACTERISTICS
M113A1 w/ACCV (Cont)

NIGHT VISION EQUIPMENT	
Sight, gunner	M36E1
Sight, driver	M19
TURRET (One-Man)	
Armament	25mm automatic cannon, 7.62mm, M60 M.G.
Traverse	360 deg continuous
Elevation	
25mm	+45 deg to -10 deg
7.62mm	pintile mount
Slew rate, maximum	45 deg/sec
Tracking rate, minimum	0.1 mil/sec
Stabilization system	Electrohydraulic
Ring gear, pitch diameter	34 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	5
AMMUNITION - Number of rounds	
7.62mm (M60)	2400 stowed
5.56mm (M16A1)	720 stowed
25mm	1200 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	100
Volts, dc	28
Batteries	2, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/VRC-64
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	5 lb CO_2
Portable	5 lb CO_2

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CHARACTERISTICS
Extended M113A1E1 w/ITV

GENERAL	
Weight, combat loaded	29500 lb
Ground pressure, combat loaded	7.5 psi
Personnel capacity	5
Fuel tank capacity	95 gallons
PERFORMANCE	
Speed on land	40 mi/h
Cruising range	250 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	40%
Trench crossing	79 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	18.6 hp/ton
ENGINE	
Make and model	Detroit Diesel 6V53T
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	275
TRANSMISSION, AUTOMATIC	
Make and model	Allison X-200-3
Type	Hydrokinetic
Steering	Hydrostatic
Brake type	Multiple wet plate
RUNNING GEAR	
Suspension type	Flat track
Springing media	Advanced torsion bar
Number of wheels	6 pr. per side
Wheel size	24 in diam, 2 1/8 in wide
Track type	Double pin
Shock absorbers	3 per side
Track pitch	6 in
Track width	15 in
Track weight	53 lbs/ft

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CHARACTERISTICS
Extended M113A1E1 w/ITV (Cont)

NIGHT VISION EQUIPMENT	
Sight, gunner	AN/TAS-4
Sight, commander	None
Sight, driver	AN/VVS-2
TURRET (One-Man)	
Armament	TOW missile launcher, 7.62mm, M60 M.G.
Traverse	360 deg continuous
Evevation	
TOW Missile Launcher	+30 deg to -31 deg
7.62-mm	pintile mount
Slew rate, maximum	45 deg/sec
Tracking rate, minimum	0.1 mil/sec
Stabilization system	Electrohydraulic
Ring gear, pitch diameter	34 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	5
AMMUNITION - Number of rounds	
7.62mm (m60)	7600 stowed
5.56mm (M16A1)	1460 stowed
TOW missiles	2 in launcher
TOW missiles	10 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	220
Volts, dc	28
Batteries	4, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/GRC-160
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	7 lb Halon in engine compartment
	5 lb Halon in personnel compartment
Portable	2.75 lb Halon

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CHARACTERISTICS
Extended M113A1E1 w/TAT-II

GENERAL	
Weight, combat loaded	31500 lb
Ground pressure, combat loaded	8.0 psi
Personnel capacity	5
Fuel tank capacity	110 gallons
PERFORMANCE	
Speed on land	38 mi/h
Cruising range	260 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	40%
Trench crossing	79 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	17.5 hp/ton
ENGINE	
Make and model	Detroit Diesel 6V53T
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	275
TRANSMISSION, AUTOMATIC	
Make and model	Allison X-200-3
Type	Hydrokinetic
Steering	Hydrostatic
Brake type	Multiple wet plate
RUNNING GEAR	
Suspension type	Flat track
Springing media	Advanced torsion bar
Number of Wheels	6 pr. per side
Wheel size	24 in diam, 2 1/8 in wide
Track type	Double pin
Shock absorbers	3 per side
Track pitch	6 in
Track width	15 in
Track weight	53 lbs/ft

LK10819
CHARACTERISTICS
Extended M113A1E1 w/TAT-II (Cont)

NIGHT VISION EQUIPMENT	
Sight, gunner	Thermal imagery
Sight, commander	Optical relay from gunner's sight
Sight, driver	AN/VVS-2
TURRET (Two-Man)	
Armament	TOW missile launcher 7.62mm, M240 Coxial M.G.
Traverse	360 deg continuous
Elevation	
7.62mm M.G.	+60 deg to -10 deg
TOW missile launcher	+30 deg to -20 deg
Slew rate, maximum	60 deg/sec
Tracking rate, minimum	0.05 mil/sec
Stabilization system	Electric
Ring gear, pitch diameter	60 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	5
AMMUNITION - Number of Rounds	
7.62mm (XM240)	800 ready/3600 stowed
7.62mm (M60)	3200 stowed
5.56mm (M16A1)	1460 stowed
TOW missiles	2 in launcher
TOW missiles	10 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	220
Volts, dc	28
Batteries	4, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/VRC-46, AN/GRC-160
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	7 lb Halon in engine compartment 5 lb Halon in personnel compartment
Portable	2.75 lb Halon

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CHARACTERISTICS
Extended M113A1E1 w/BAT-II

GENERAL

Weight, combat loaded	33,500 lb
Ground pressure, combat loaded	8.5 psi
Personnel capacity	9
Fuel tank capacity	110 gallons

PERFORMANCE

Speed on land	33 mi/h
Cruising range	250 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	40%
Trench crossing	79 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	16.4 hp/ton

ENGINE

Make and model	Detroit Diesel 6V53T
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	275

TRANSMISSION, AUTOMATIC

Make and model	Allison X-200-3
Type	Hydrokinetic
Steering	Hydrostatic
Brake type	Multiple wet plate

RUNNING GEAR

Suspension type	Flat track
Springing media	Advanced torsion bar
Number of Wheels	6 pr. per side
Wheel size	24 in diam, 2-1/8 in wide
Track type	Double pin
Shock absorbers	3 per side
Track pitch	6 in
Track width	15 in
Track weight	53 lbs/ft

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LK10820
CHARACTERISTICS
Extended M113A1E1 w/BAT-II (Cont)

NIGHT VISION EQUIPMENT	
Sight, gunner	M36E2 day/night
Sight, commander	None
Sight, driver	AN/VVS-2
TURRET (Two-Man)	
Armament	25-mm automatic cannon 7.62-mm, M240 coaxial M.G.
Traverse	360 deg continuous
Elevation	+60 deg to -10 deg
Slew rate, maximum	60 deg/sec
Tracking rate, minimum	0.05 mil/sec
Stabilization system	Electric
Ring gear, pitch diameter	60 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	9
AMMUNITION - Number of Rounds	
25mm	300 ready/600 stowed
7.62mm (XM240)	800 ready/1400 stowed
7.62mm (M60)	2200 stowed
5.56mm (M16A1)	2160 stowed
Dragon Missiles	3 stowed
LAW (M72A2)	3 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	220
Volts, dc	28
Batteries	4, type 6TN, 100 amp-hr
COMMUNICATIONS (COMMANDER VEHICLE)	
Radio	AN/VRC-46, AN/GRC-160
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	7 lb Halon in engine compartment 5 lb Halon in personnel compartment
Portable	2.75 lb Halon

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CHARACTERISTICS
Extended M113A1E1 w/TBAT-II

GENERAL	
Weight, combat loaded	35,000 lb
Ground pressure, combat loaded	8.9 psi
Personnel capacity	9
Fuel tank capacity	110 gallons
PERFORMANCE	
Speed on land	30 mi/h
Cruising range	240 mi
Turning radius	Pivot to infinite
Slope	60%
Side slope	40%
Trench crossing	79 in
Vertical wall climbing	24 in
Gross horsepower-to-weight ratio	15.7 hp/ton
ENGINE	
Make and model	Detroit Diesel 6V53T
Displacement	318 Cu In
Type	2 Cycle
Fuel	Diesel
Gross horsepower	275
TRANSMISSION, AUTOMATIC	
Make and model	Allison X-200-3
Type	Hydrokinetic
Steering	Hydrostatic
Brake type	Multiple wet plate
RUNNING GEAR	
Suspension type	Flat track
Springing media	Advanced torsion bar
Number of wheels	6 pr. per side
Wheel size	24 in diam, 2-1/8 in wide
Track type	Double pin
Shock absorbers	3 per side
Track pitch	6 in
Track width	15 in
Track weight	53 lbs/ft

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LK10821
CHARACTERISTICS
Extended M113A1E1 w/TBAT-II (Cont)

NIGHT VISION EQUIPMENT	
Sight, gunner	Thermal imagery
Sight, commander	Optical relay from gunner's sight
Sight, driver	AN/VVS-2
TURRET (Two-Man)	
Armament	25mm automatic cannon, TOW missile launcher 7.62mm, M240 coaxial M.G.
Traverse	360 deg continuous
Elevation	
25mm cannon & 7.62mm M.G.	+60 deg to -10 deg
TOW missile launcher	+30 deg to -20 deg
Slew rate	60 deg/sec
Tracking rate, minimum	0.05 mil/sec
Stabilization system	Electric
Ring gear, pitch diameter	60 in
SQUAD WEAPONS	
Machine gun, M60, 7.62mm	1
Rifles, M16A1, 5.56mm	9
AMMUNITION - Number of Rounds	
25mm	300 ready/600 stowed
7.62mm (XM240)	800 ready/1400 stowed
7.62mm (M60	2200 stowed
5.56mm (M16A1)	2160 stowed
TOW missiles	2 in launcher
TOW/DRAGON missiles	5 stowed, any combination
LAW (M72A2)	3 stowed
ELECTRICAL SYSTEM	
Generator	
Amperes	220
Volts, dc	28
Batteries	4, type 6TN, 100 amp-hr
COMMUNICATIONS	
Radio	AN/VRC-46, AN/GRC-160
ARMOR HULL	5083 aluminum
FIRE EXTINGUISHER	
Fixed	7 lb Halon in engine compartment 5 lb Halon in personnel compartment
Portable	2.75 lb Halon

ITV TURRET, IFV CHASSIS

General	
Weight, combat loaded	41,900 lb.
Weight, less fuel, crew, and OVE	
Weight, air transportable	
Ground pressure, combat loaded	6.6 psi
Personnel capacity	5
Fuel tank capacity	190 gallons
Performance	
Speed on land	42 mi/h
Speed in water, with track	4.5 mi/h
Cruising range	368
Turning radius	Pivot to infinite
Slope	60%
Side slope	40%
Trench crossing	100 in
Vertical wall climbing	36 in
Gross horsepower-to-weight ratio	24
Engine	
Make and model	Cummins VTA-903
Displacement	903 $in.^3$
Type	4 cycle
Fuel	Diesel
Gross horsepower	500
Transmission, Automatic	
Make and model	GE HMPT-500
Type	Hydromechanical
Steering	Hydrostatic
Brake type	Multidisc, oil cooled
Running Gear	
Suspension type	Return roller
Springing media	Torsion bar
Number of wheels	6 pr. per side
Wheel size	24 in. diam. 4 in. wide
Track type	Steel single pin with detachable rubber pad
Shock absorbers	3 per side
Number of shoes	83, left; 82, right
Track pitch	6 in
Track width	21 in
Night Vision Equipment	
Sight, gunner	Thermal imagery
Sight, commander	Panoramic day sight only
Sight, driver	AN/VVS-2

ITV TURRET

Armament	TOW missile launcher 7.62-mm machine gun on turret
Traverse	360 deg. continuous
Elevation	
TOW missile launcher	+38 deg. -30 deg.
Ring gear, pitch diameter	34.2 in.

Squad Weapons

Machine gun, M60, 7.62-mm	1
Rifles, M16A1, 5.56-mm.	5
TOW Dismount Capability	

Ammunition	Ready/Stowed
7.62-mm (for turret)	4400 stowed
7.62-mm (M60)	3200 stowed
5.56-mm (M16A1)	1460 stowed
TOW missiles	2/10
LAW (M72A2)	3 stowed

Electrical System

Generator	
Amperes	220
Volts, dc	28
Batteries	4 type 6TN, 100 amp hr 12 volt each

Communications

Radio	AN/VRC-12 AN/PRC-77

Armor

Top and front slopes	5083 aluminum
Vertical sides and rear	Spaced laminate armor
Bottom	5083 sluminum with antimine applique
Side Slopes	7039 aluminum

Fire Extinguisher

Fixed	7 lb. (3.2 kg) Halon in engine compartment, (2) 5 lb. (2.3 kg) Halon in personnel compartment
Portable	2.75 lb. (1.2 kg) Halon

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APPENDIX C

VULNERABILITY VERSUS SIZE TRADE-OFF

VULNERABILITY VERSUS SIZE TRADE-OFF

Even though vulnerability of the respective vehicles is not part of the technical risk associated with the two vehicle chassis, it is part of the overall risk associated with fielding either of the vehicles. For this reason a cursory evaluation of the relative survivability of the SM113 and the IFV was conducted using data previously generated for the special study group. For this examination the threat weapons were the direct fire weapons of two classes, the small caliber (machine guns and automatic cannons) and the larger caliber weapons available to the threat infantry. These types were picked to represent the two basic types of weapons to which the vehicles would be exposed. The data illustrate the relative vulnerability (and survivability) characteristics of the two vehicles (i.e. one with less armor protection, and one with more exposed area). Two types of data were used for the study, (1) kills per burst for the small caliber weapons and (2) probability of hit for the larger caliber weapons. For the larger caliber weapons, the probability of kill given a hit was assumed to be the same for the both vehicles since penetration of the armor protection is assured and the amount of ammunition and other equipment in the vehicles is the same. The kill and hit data were then tabulated and the survivability ($1-P_k$) for each vehicle was calculated. The relative survivability was then computed. The table below presents the relative survivability of the SM113 to the IFV. The values given represent the ratio of the survivability of the SM113 to the IFV against six representative weapons. The small caliber weapons are three that span a range of small calibers capable of penetrating the vehicles. In the large caliber trio of weapons are both guided and free flight types.

SM113/IFV RELATIVE SURVIVABILITY
(Fully exposed stationary vehicles)

THREAT WEAPON

Range (meters)	Small Caliber Weapons (1)	Small Caliber Weapons (2)	Small Caliber Weapons (3)	Large Caliber Weapons (1)	Large Caliber Weapons (2)	Large Caliber Weapons (3)
200	0.72	0.28	0.45	1.25	1.00	--
400	0.93	0.50	0.82	1.04	1.42	--
800	--	0.86	0.94	--	1.17	1.20
1200	--	--	--	--	1.08	1.20
2000	--	--	--	--	--	1.20
3000	--	--	--	--	--	1.20

These data clearly illustrate that the increased armor protection of the IFV gives it an advantage at the closer ranges where the predominant fire

will be from small caliber weapons. But its larger size is a disadvantage at the longer ranges where the larger caliber weapons would be employed against it. In the hull defilade posture both vehicles would only have the turret exposed and the vulnerability would be the same.

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APPENDIX D

INFORMATION SOURCES

The following is a listing of personnel contacted and reports reviewed in preparation of this report.

I. PERSONNEL CONTACTED

A. TARADCOM

1. Concept Development

Cliff Bradley

Roland Asoklis

Lynn Martin

Ted Puuri

2. Track & Suspension

Dick Siorek

3. Power Train & Cooling

Stan Darson

Chris Van Der Zon

Ed Rambie

Casimir Grzeszkowiak

Wayne Wheelock

4. M113 PMO

Tony Comito

5. Reliability & Quality Assurance

Dr. Len Lamberson

Joe Knofczyncki

B. FVS PMO

Jerry Chapin

Brent Sherman

Norb Slawski

C. MTD, APG

Eddie Meadows

Carl Domanski

Leonard Conrad

Jack Robinson

Pete McKay

Ron Lenert

D. FMC

Burt Long

Tom Cronogue (US Gov't Rep.)

E. Detroit Diesel Allison

LeRoy Johnson

Bob Tuer

Ron Lund

II. Reports

A. Wedemeyer, James B., Interim Report On Development Test II, Full-Load Cooling Capability Phase of Carrier, Armored, Personnel, M113A1E1 (Rise Power Train), TECOM Project No. 1-VC-010-113-061, YPG Report No. 335, January 1978, Yuma Proving Ground, UNCLASSIFIED.

B. Smith, David, Product Improvement Test of Carrier, Personnel, Full-Tracked, Armored, M113A1 First and Final Report, USATECOM Project No. 1-VG-013-113-001, YPG Report No. 6805, September 1970, Yuma Proving Ground, UNCLASSIFIED.

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